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IDENTIFIERS Oklahoma

## ABSTRACT

This module on introductory heating, ventilating, and air conditioning (HVAC) is one of a series of modules designed to teach basic skills necessary for entry-level employment in this field. The module contains four instructional units that cover the following topics: (1) HVAC materials; (2) HVAC tools; (3) HVAC layout; and (4) HVAC basic skills. Each instructional unit follows a standard format that includes some or all of these eight basic components: performance objectives, suggested activities for the instructor, information sheets, assignment sheets, job sheets, transparency masters, tests, and answers to tests and assignment sheets. All of the unit components focus on measurable and observable learning outcomes, and are designed for use in more than one lesson or class period. A competency profile for evaluating trainees is included. (KC)

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# The Associated General Contractors of America

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## Introduction to Heating, Ventilation and Air Conditioning (HVAC)

## Introduction to Construction Series

89-006402

2

instructor edition

# INTRODUCTION TO HEATING, VENTILATION, AND AIR CONDITIONING

Developed as a Cooperative Project by  
The Associated General Contractors of America  
William K. Healy, Chairman, Manpower and Training Committee  
and  
**Oklahoma State Board of Vocational and Technical Education**  
John Folks, Chairman  
Roy Peters, Jr., Director

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# INTRODUCTION TO HEATING, VENTILATION, AND AIR CONDITIONING COMPETENCY PROFILE

Student: \_\_\_\_\_ Soc. Sec. No. \_\_\_\_\_  
 Last First MI

|                               |                        |        |
|-------------------------------|------------------------|--------|
| PROGRAM                       | Grade 9 10 11 12 Adult | SCHOOL |
| INSTRUCTOR                    | SCHOOL ADDRESS         | PHONE  |
| STUDENT'S HOME ADDRESS        | DATE OF BIRTH          | PHONE  |
| STUDENT'S EMPLOYER            | ADDRESS                | PHONE  |
| CONTACT IN CASE OF EMERGENCY: |                        | PHONE  |
| ADDRESS                       |                        |        |
| OR                            |                        |        |
| ADDRESS                       |                        | PHONE  |

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## ON-JOB TRAINING/WORK EXPERIENCE

| DURATION OF EMPLOYMENT | JOB TITLE | EMPLOYER | SUPERVISOR'S NAME | ADDRESS OF EMPLOYER | PHONE |
|------------------------|-----------|----------|-------------------|---------------------|-------|
|                        |           |          |                   |                     |       |
|                        |           |          |                   |                     |       |
|                        |           |          |                   |                     |       |

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# SPECIFIC JOB COMPETENCIES

Directions: Evaluate the trainee using the rating scale below and check the appropriate number to indicate the degree of competency achieved. The numerical ratings of 4, 3, 2, 1, and 0 are not intended to represent the traditional school grading system of A, B, C, D, and F. The descriptions associated with each of the numbers focus on level of student performance for each of the tasks listed below. The written test score line is provided for optional teacher use. It may not be applicable in all cases. "NA" is an appropriate entry in such instances.

- Rating Scale
- 4 — Skilled — can perform independently with no additional training.
  - 3 — Moderately Skilled — has performed independently during training program, limited additional training may be required.
  - 2 — Limited Practice — has practiced during training program, additional training is required to develop skill.
  - 1 — Exposure Only — general information provided with no practice time, close supervision needed and additional training required.
  - 0 — No Exposure — no information or practice provided during training program, complete training required.

4 3 2 1 0  
 HVAC Materials  
 1. \_\_\_\_\_  
 WRITTEN TEST SCORE \_\_\_\_\_

3 2 1 0  
 HVAC Tools  
 1. \_\_\_\_\_  
 WRITTEN TEST SCORE \_\_\_\_\_

3 2 1 0  
 HVAC Layout  
 1. Solve problems using the friction loss per 100 feet chart  
 2. Solve problems using the friction chart  
 3. Design an air distribution system from a drawing  
 4. \_\_\_\_\_  
 WRITTEN TEST SCORE \_\_\_\_\_

3 2 1 0  
 HVAC Basic Skills  
 1. Make a flare with compression-type flaring block  
 2. Make a flare with generating-type flaring block  
 3. Make a swage joint  
 4. Make a 90-degree bend in copper tubing  
 5. Make a 180-degree bend in copper tubing  
 6. Make a 45-degree offset bend in copper tubing  
 7. Cut, ream, and join copper tubing using a flare joint  
 8. Cut, ream, and join copper tubing using the compression method  
 9. Cut, ream, and join copper tubing using the sweat method  
 10. Cut, ream, and join copper tubing using the swage method  
 11. Construct a tubing project  
 12. Measure and mark a predetermined length of pipe  
 13. Cut, ream, and thread a piece of one-inch steel pipe  
 14. Cut, ream, and join plastic pipe  
 15. \_\_\_\_\_  
 WRITTEN TEST SCORE \_\_\_\_\_

## Use of This Document

This document can be used to record information about the student and the skills mastered by the student. This information is useful in documenting student progress during the training program and to provide information about the student's qualifications to potential employers and for entry into advanced training programs. Instructors using AGC-CIMC instructional materials are authorized to reproduce this document as required for use in their training programs.

INTRODUCTION TO HEATING,  
VENTILATION, AND AIR CONDITIONING

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## FOREWORD

In 1985, The Associated General Contractors of America (AGC) met with representatives of the Oklahoma Curriculum and Instructional Materials Center (CIMC) to discuss the possibilities of developing, as a cooperative project, a course of instruction designed for training individuals who choose to seriously explore careers in construction.

This publication is the result of those original discussions and close coordination among general contractors and vocational educators. This series represents a conscious effort to coordinate the practical experience of personnel in the construction industry with the best instructional methods of those in the field of vocational education.

Although this series reflects a systematic approach to instructional materials development and the latest in educational technology innovations, the information in *Introduction to Heating, Ventilation, and Air Conditioning* should be adapted and modified to coincide with local conditions.

Dr. Roy Peters, Jr., Director  
Oklahoma State Department of  
Vocational and Technical Education

William K. Healy, Chairman  
Manpower and Training Committee  
The Associated General Contractors  
of America

## PREFACE

For many years The Associated General Contractors of America (AGC) has recognized the need for providing quality competency-based instructional materials for the construction industry. AGC and the Oklahoma State Department of Vocational and Technical Education have met this challenge by providing nationally recognized curriculum and services since 1972. In 1986 AGC and Oklahoma's Curriculum and Instructional Materials Center (CIMC) determined a significant need for a series that would address training needs of open shop contractors, preapprenticeship programs, multi-craft high school programs, technology education programs, CVET, and cooperative education programs. The Introduction to Construction Series was designed with the flexible training requirements of these groups in mind.

The Introduction to Construction Series begins with *Fundamentals of Construction* and progresses to twelve spin-off specialty publications. *Fundamentals of Construction* covers basic knowledge necessary for all individuals in construction. Each specialty area covers basic skills necessary for entry-level employment. Both vocational education and the construction industry offer more advanced courses in each specialty area and should be considered by individuals wishing to establish careers in the industry. Competency profiles (provided in the teacher edition) for the Introduction to Construction Series articulate with several more advanced AGC publications as well as publications developed by the Mid-America Vocational Curriculum Consortium (MAVCC).

Publications in this series include:

- Introduction to Bricklaying
- Introduction to Carpentry
- Introduction to Concrete Masonry
- Introduction to Ironwork
- Introduction to Electricity
- Introduction to Plumbing
- Introduction to Heating, Ventilation,  
• and Air Conditioning
- Introduction to Sheet Metal
- Introduction to Roofing
- Introduction to Drywall
- Introduction to Insulation
- Introduction to Welding

## USE OF THIS PUBLICATION

### Instructional Units

*Introduction to Heating, Ventilation, and Air Conditioning* contains one section and four instructional units. A standard format was established in 1970 for development of instructional materials for all Oklahoma vocational teachers. This format includes eight basic components that form a unit of instruction: performance objectives, suggested activities for the instructor, information sheets, assignment sheets, job sheets, transparency masters, tests, and answers to tests and assignment sheets. Depending on specific objectives, there may or may not be transparency masters, assignment sheets, and job sheets included in the unit of instruction.

All of the unit components "zero in" on measurable and observable learning outcomes. Instructors are encouraged to supplement, personalize, localize, and motivate with these materials in order to develop a complete teaching/learning process.

Units of instruction are designed for use in more than one lesson or class period of instruction. Careful study of each unit of instruction by the instructor will help him or her determine the following

- Amount of material that can be covered in each class period
- Skills that must be demonstrated
  - Supplies and equipment needed
  - Amount of practice needed
  - Amount of class time needed for demonstrations
- Supplementary materials, such as pamphlets and filmstrips, that must be ordered
- Resource people who must be contacted

### Performance Objectives (white pages)

Each unit of instruction is based on the performance needed for successful employment in an occupational area. Performance objectives are stated in two forms: unit objectives, stating the subject matter to be covered in a unit of instruction; and specific objectives, stating the performance necessary to reach the unit objective.

Since the objectives of the unit provide direction for the teaching/learning process, it is important that instructors and students have a common understanding of the intent of the objectives.

The objective sheet should be given to students and referred to throughout the teaching/learning process. This will help answer any questions concerning performance requirements for each instructional unit. The objectives can also help determine teaching strategies and instructional methods. Prepare for each unit by deciding how each objective can best be taught.

The objective sheet may also be used as a quick pretest to determine students' prior knowledge and to determine whether further study or activities are necessary. Teachers should feel free to modify, delete, or add objectives in order to meet the needs of the students and community. When changes in objectives are made, the teacher should remember to supply the needed information, assignment and/or job sheets, and criterion test items.

### **Suggested Activities** (pink pages)

Suggested activities are included only in teacher materials. The suggested activities pages include an outline of the unit contents and an instructor's guide designed to assist teachers in planning their presentation of the unit. The instructor's guide provides suggestions for delivery and/or presentation during the instructional process. Read the suggested activities before teaching the units so that supplemental materials can be obtained, audiovisual materials prepared, and outside resources contacted. Duties of the teacher will vary according to the particular unit.

The references that are listed in the suggested activities are ones used in the development of each unit. They should be used by the teacher to supplement her or his knowledge of the subject area or to help students with particular interests or occupational objectives in the area covered.

The suggested activities section of the unit also includes supplements and transparency masters. Each of these components provides information in a special way. Supplements may consist of motivational materials, review or practice materials such as crossword puzzles and self-tests, or charts and reference materials. Supplements are designed to be copied and distributed to individual class members or to the class as a whole. Suggestions for their use are included in the instructor's guide. Transparencies direct the class' attention to the topic of discussion. Transparencies may present new information, or they may reinforce information presented in the information sheet. They are particularly effective when identification or analysis is necessary. Order transparencies from the Curriculum and Instructional Materials Center, or make transparencies and place them in the notebook where they will be immediately available for use.

### **Information Sheet** (green pages)

The information sheet provides "must know" content essential for meeting the cognitive (knowledge level) objectives of the unit. The information is written in a topical-outline form and is keyed to the specific objectives.

Teachers will find that the information sheet serves as an excellent guide for presenting background knowledge necessary to develop the skills specified in the unit objective. The information sheet may also be used for coordination activities and advisory committees.

Students should read the information sheet before the information is discussed in class. Space provided in margins for students and teachers to add notes that supplement, localize, personalize, or provide motivation for each unit.

### **Assignment Sheets** (brown pages)

Assignment sheets give students a chance at problem solving, self-assessment, and/or practical experience. They assist students in the application of knowledges that are necessary prerequisites to skill development. Assignment sheets may be given to the student for completion in class or may be used for homework assignments. Answer sheets are provided when appropriate and can be used by the student and/or teacher for checking student progress. The scores of those assignment sheets listed in the specific objectives should be averaged with the unit test score, as the skills addressed in these assignment sheets are considered necessary in meeting the unit objective.



### **Job Sheets (blue pages)**

Job sheets are another important segment of a unit of instruction. The job sheets provide a list of equipment, tools, and materials needed to complete a manipulative or psychomotor skill. They describe a step-by-step procedure needed to complete each task or job. Diagrams, photographs, and illustrations are provided to assist students in achieving the skill.

The teacher should demonstrate to students the procedures outlined in each job sheet. Furthermore, the teacher needs to localize the job sheet according to the equipment and supplies available in the local lab or shop situation. Job sheets also furnish potential employers with a picture of the skills being taught and the performances they might reasonably expect from a person who has had this vocational instruction.

Job sheet performance should be evaluated by the instructor and averaged with the unit test score, as the skills addressed in the job sheets are considered necessary in meeting the unit objective.

### **Tests (White pages)**

Tests are included only in teacher materials. The test provides criterion-referenced evaluation of every objective listed in the unit of instruction. It is crucial to note that both paper/pencil and performance objectives must be evaluated.

It is recommended that the tests be divided into shorter tests covering three or four objectives at a time and given soon after those objectives have been covered. A selection of questions from the units covered may be used for final tests at the end of each term if desired. If objectives have been added, deleted, or modified, be sure to make the changes on the test.

The acceptable response on a unit test, 80 percent in most units, may be raised or lowered to fit the topic or students' ability levels. The percentage applies to the overall score, not to each question. The final unit grade should be obtained by using the paper/pencil score and evaluations of student demonstrations of the desired skills.

### **Answers to Test and Assignment Sheets (pink pages)**

Answers to test and assignment sheets are components designed to assist the teacher in evaluation of student performances.

### **Page Numbering**

Each publication from the Curriculum and Instructional Materials Center (CIMC) is assigned a specific abbreviation. For example, *Introduction to Heating, Ventilation, and Air Conditioning* has been abbreviated ITHVAC. The units are then numbered consecutively within each section. An example of a page number is ITHVAC-1. Since CIMC publications are loose leaf, this system of page numbering was adopted so that pages from different manuals would not get mixed up.

### **Methods of Disseminating Material**

For best results, provide student materials for each student. Student materials contain everything but the test, supplements, answers to assignment sheets, and suggested activities.

### **Teaching Methods**

It is a challenge to keep students motivated. Supplement the objectives by providing the "why," personal experiences, and current information. Prepare for each unit by deciding how each objective can best be taught. Allow students to become involved in preparing and planning.

### **Competency Profiles**

Competency profiles are folders used to document student performances. The profile contains a list of the specific job competencies that a student should achieve prior to leaving the training program. A competency profile master is provided in the instructor edition of each publication. Duplicate the profile and distribute to students as required.

**Other AGC Publications:** AGC updates curriculum products on a continuing basis. For a free catalog describing other AGC products, call the AGC National office at 1-202-393-2040.

## CORRECTIONS AND SUGGESTIONS

The Curriculum and Instructional Materials Center wants to provide vocational instructors and students with materials that are accurate and effective. Although the CIMC strives to maintain the highest standards of development and production, oversights occasionally do occur. If you find any errors in this or other CIMC publications, or have suggestions for improving their usefulness in vocational programs, please notify the CIMC staff. One easy way of pointing out errors is to make a photocopy of the affected pages and to indicate the correction on the copy. You can then mail the information to the CIMC, where it will be used to correct the publication before the materials are reprinted.

To ensure that the material is updated on a timely basis, it is important that you notify the CIMC of necessary corrections as soon as possible after discovering the error. Do not assume that someone else will notice the error and inform the CIMC; other users may be making the same assumption. Please send corrections and recommendations for improving this publication to the following address:

Curriculum Development Coordinator  
Curriculum and Instructional Materials Center  
Oklahoma State Department of Vocational and  
Technical Education  
1500 W. Seventh Avenue  
Stillwater, Oklahoma 74074-4364

## HVAC MATERIALS UNIT I

### UNIT OBJECTIVE

After completing this unit, the student should be able to identify materials associated with HVAC and various applications for materials. The student will show this knowledge by completing the unit test with a minimum score of 80 percent.

### SPECIFIC OBJECTIVES

After completing this unit, the student should be able to

1. Match terms associated with HVAC materials to their correct definitions.
2. Select from a list types of tubing used in HVAC.
3. Match the color coding of cartons and tags with the correct type of copper tubing.
4. State applications for nominal size copper tubing.
5. State applications for ACR copper tubing.
6. State applications for aluminum tubing.
7. State applications for steel tubing.
8. State applications for neoprene flexible refrigerant hose.
9. Identify tubing fittings.
10. Identify flexible refrigerant hose and quick-connect fittings.
11. Match types of pipe used in HVAC to their applications.
12. Identify pipe fittings.
13. State methods used to measure pipe.
14. Select from a list materials needed to join pipe.
15. Name types of air-treatment units.
16. Select from a list basic components of a cooling system.
17. Select from a list major components in furnace construction.
18. Identify commonly used HVAC duct fittings.



## OBJECTIVE SHEET

19. Identify common types of registers and diffusers.
20. Select types of HVAC hangers and supports.

HVAC MATERIALS  
UNIT I

## SUGGESTED ACTIVITIES

- I. Unit contents
  - A. Objective sheet
  - B. Suggested activities
  - C. Transparency masters
    1. TM #1 — Basic Components of a Cooling System
    2. TM #2 — Major Components in Furnace Construction
  - D. Information sheet
  - E. Test
  - F. Answers to test
- II. Instructor's guide
  - A. Review unit and plan presentation.
  - B. Obtain materials to supplement unit.
    1. Catalogs of materials from manufacturers
    2. Literature and advertisements from material companies and suppliers
    3. Safety posters
    4. Plans and specifications showing types, sizes, and layouts of materials
    5. Copies of local and state codes with their specifications
    6. Transparency masters and competency profiles

(NOTE: A master of the competency profile for this book is provided at the front of the instructor edition. You may duplicate the profile and distribute it to students as needed.)
  - C. Introduce unit to students.
    - Discuss the common uses of tubing, iron pipe, plastic pipe, and their fittings.
    - Display safety posters.
    - Display literature and advertisements from material companies.
    - Have students review material catalogs.
  - D. Provide students with objective sheet.



## SUGGESTED ACTIVITIES

- E. Discuss unit and specific objectives.
  - F. Provide students with information sheet.
  - G. Discuss information sheet.
1. Use Information Sheet, Section I, to discuss terms and definitions associated with HVAC materials.
    - Show students examples or illustrations of appropriate terms.
    - Point out the importance of knowing terms and definitions for common understanding.
  2. Use Information Sheet, Sections II and III, to discuss types of tubing used in HVAC.
    - Exhibit samples of the different types and sizes of tubing.
    - Discuss the different sizes, types, and color coding of copper tubing.
    - Provide the class with plans specifying each type and size of tubing.
  3. Use Information Sheet, Sections IV through VIII, to discuss applications for copper tubing, aluminum tubing, steel tubing, and neoprene flexible hose.
    - Discuss applications for the different types of tubing. Discuss how some tubings can be used interchangeably while others must be used only for specific applications.
    - Compare the use of rigid copper tubing to flexible copper tubing.
    - Compare the applications of the different types of tubing such as steel, aluminum, and plastic.
  4. Use Information Sheet, Section IX, to discuss tubing fittings.
    - Display samples of flared fittings, flare-to-pipe fittings, compression fittings, and sweat fittings.
    - Discuss the resemblance between some of the different fittings.
    - Discuss the differences in threads and thread sizes.
    - Discuss the various shapes of fittings and why they are shaped as they are.
    - Discuss why a flared fitting may be used instead of a compression or sweat fitting or vice versa.
    - Discuss why and where flare-to-pipe fittings may be used.



## SUGGESTED ACTIVITIES

5. Use Information Sheet, Section X, to discuss flexible refrigerant hose and quick-connect fittings.
  - Display samples of the various fittings.
  - Discuss how these fittings work with flexible hose and where they may be used.
  - Discuss how and why the quick-connect fittings are used. For example, the cutter type is used on precharged refrigerant lines, and the refrigerant charge will be lost if the line is removed after it has been installed on a system. The spring-loaded seal is used on precharged refrigerant lines and may be removed from a system without losing a charge.
6. Use Information Sheet, Section XI, to discuss applications of pipe used in HVAC operations.
  - Discuss the different types of pipe.
  - Display samples of the different types of pipe.
  - Discuss and compare applications for the different types of pipe.
  - Discuss how PVC pipe is being used more frequently than iron pipe for residential operations in some areas.
  - Discuss why black iron pipe, not galvanized pipe, is used for gas and steam lines.
7. Use Information Sheet, Section XII, to discuss pipe fittings.
  - Display samples of the various pipe fittings.
  - Allow students to examine the fittings and have them identify the different types.
  - Explain why the brass fittings are used on copper rather than on iron.
  - Demonstrate how simply the PVC fittings work with PVC pipe. Explain how much more economical they are than copper and iron.
8. Use Information Sheet, Section XIII, to discuss methods used to measure pipe.
  - Discuss the importance of correct pipe measurement.
  - Demonstrate how to measure a piece of pipe using end-to-end method.
  - Demonstrate how to measure a piece of pipe using end-to-center.
  - Demonstrate how to measure a piece of pipe using center-to-center method.



## SUGGESTED ACTIVITIES

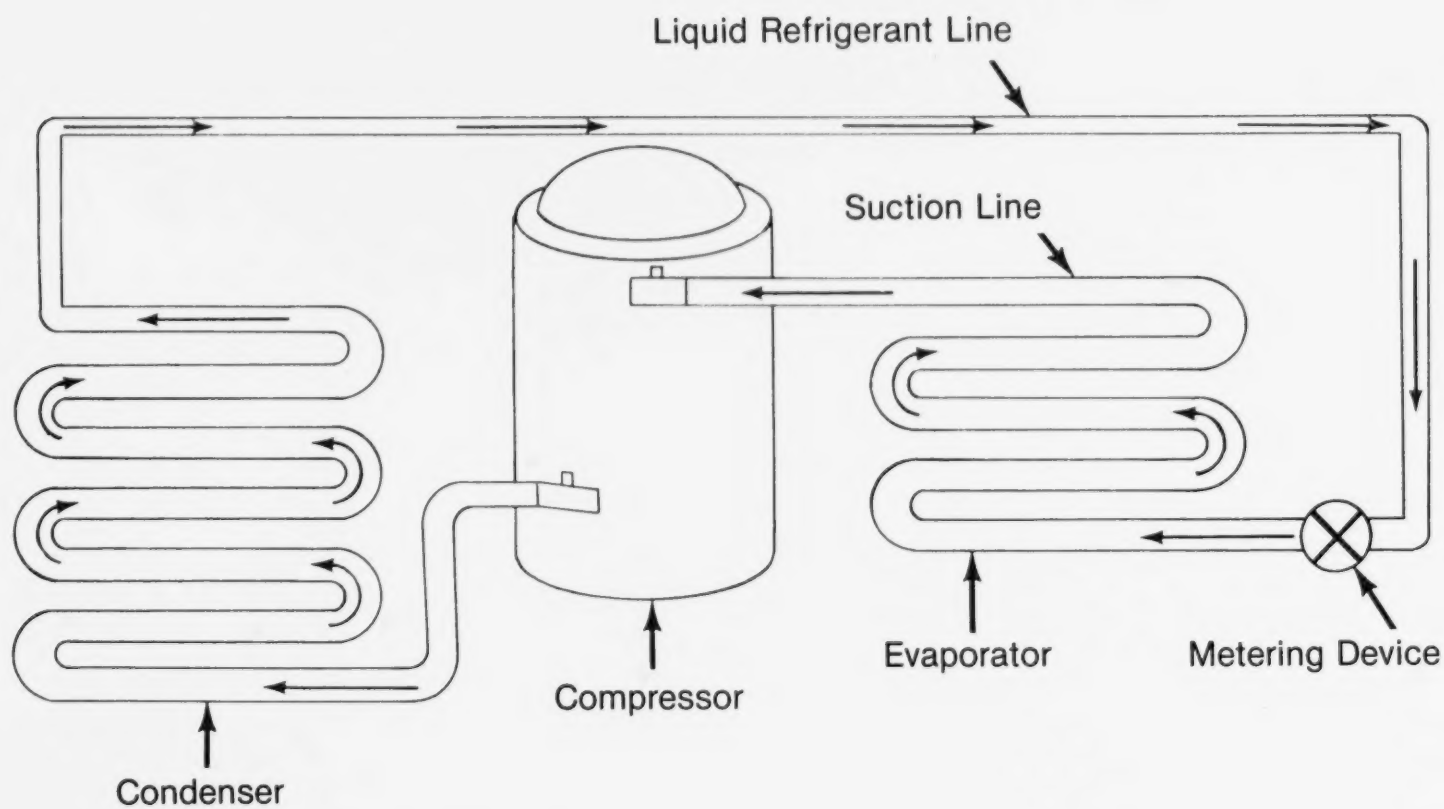
- Discuss with students which method of measurement will work better under certain circumstances.
  - Have the students demonstrate how to measure a piece of pipe using all three methods.
  - Give each student a particular job of measuring pipe using only one of the three methods; then have students explain why they used that particular method.
9. Use Information Sheet, Section XIV, to discuss materials needed to join pipe.
- Display samples of the soldering and welding materials listed in the information sheet.
  - Have students identify the different materials.
  - Discuss how and why the different materials are used.
  - Discuss how and why flux is used.
  - Discuss why some fittings are welded and why some are soldered.
10. Use Information Sheet, Section XV, to discuss air-treatment units.
- Show students examples or illustrations of the units.
  - Discuss the function of each of the units.
  - Have students tell how many of these units they have in their homes.
11. Use Information Sheet, Sections XVI and XVII, to discuss components of a cooling system and a heating system.
- Show students examples or illustrations of these components.
  - Discuss the functions of each of the components.
  - Use Transparencies #1 and #2 to reinforce your discussion.
  - Invite a HVAC specialist to the class to explain the functions of cooling and heating systems.
12. Use Information Sheet, Section XVIII, to discuss duct fittings.
- Provide the class with samples of the various types of duct fittings.
  - Discuss the shapes, sizes, and purposes of duct fittings.
  - Show students an illustration of a trunk system, and show how all the parts fit together.
  - Show different fittings to students and have them tell you where that particular fitting is attached and what its function is.

## SUGGESTED ACTIVITIES

13. Use Information Sheet, Section XIX, to discuss common types of registers and diffusers.
    - Provide the class with samples of the various types of registers and diffusers.
    - Have students identify the registers and diffusers and discuss their functions.
    - Provide students with pictorial views of heating systems such as loop perimeter system, radial perimeter system, extended plenum system, crawl space plenum system, and graduated trunk system. Have students point out where the various registers and diffusers should be used.
  14. Use Information Sheet, Section XX, to discuss types of HVAC hangers and supports.
    - Provide the class with samples of the various types of duct hangers, pipe hangers, and supports.
    - Have students identify the hangers and supports.
    - Have students suggest other methods or materials that could be used to support ducts and pipe.
    - Discuss how the various hangers and supports are used.
    - Demonstrate how the various hangers and supports are used, and give the students the opportunity to demonstrate their uses.
- H. Give test.
- I. Critique test and discuss in class.
- J. Reteach and retest as necessary.
- K. Complete appropriate sections of competency profiles.
- III. Unit references.
- A. Eckes, William and Dan Fulkerson. *Air Conditioning and Refrigeration Book III*. Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, Inc., 1981.
  - B. Eckes, William and Dan Fulkerson. *Air Conditioning and Refrigeration Book IV*. Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, Inc., 1981.
  - C. Wantiez, Gary W. *Air Conditioning and Refrigeration Fundamentals*. Stillwater, Oklahoma. Mid-America Vocational Curriculum Consortium, Inc., 1984.
  - D. Zinngarbe, Claude J. *Sheet Metal Blueprint Reading for the Building Trades*. Albany, NY: Delmar Publishers, a division of Litton Educational Publishing, Inc., 1984.



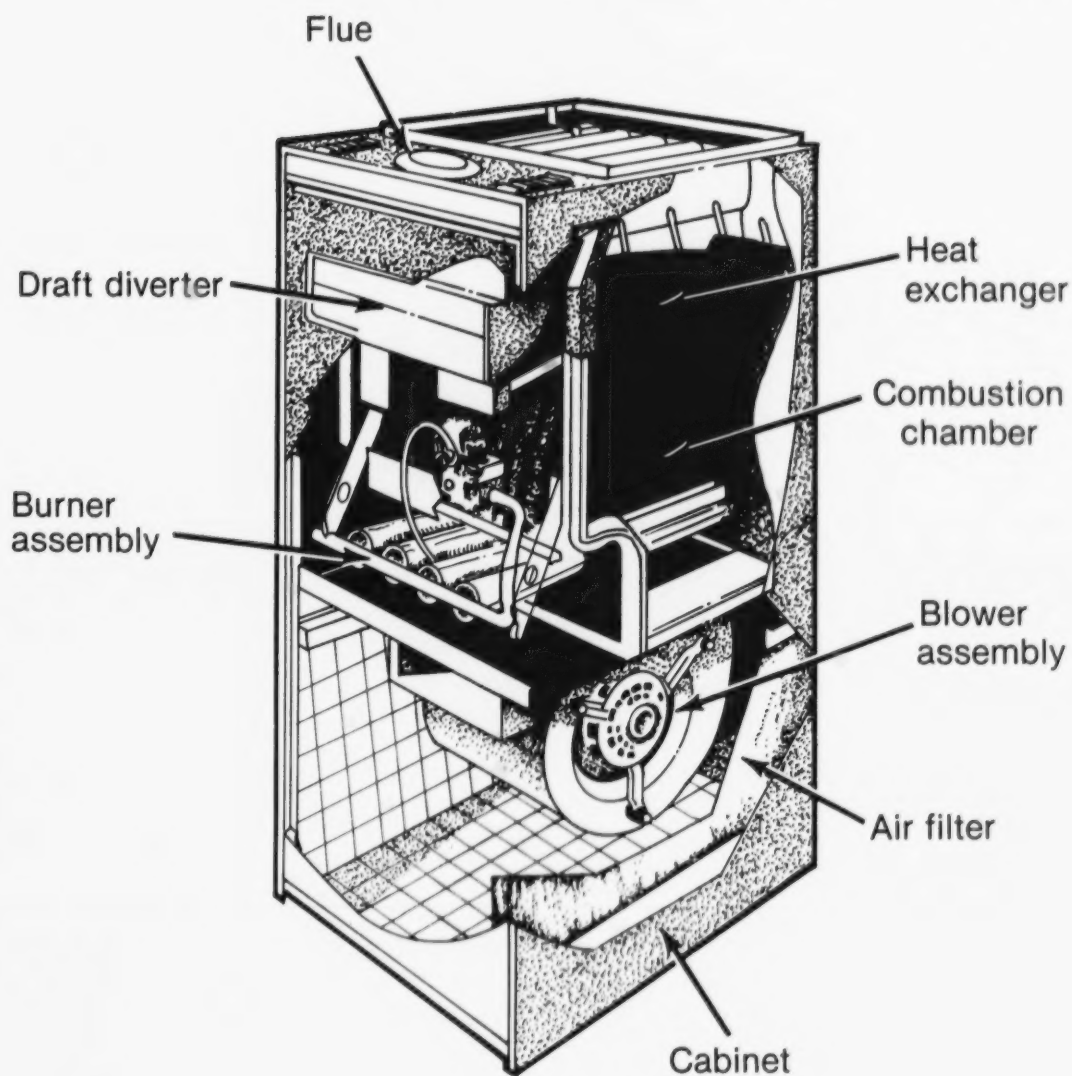
# Basic Components of a Cooling System



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# Major Components in Furnace Construction (Gas Fired)



Used with permission of Lennox Industries, Inc., Dallas, Texas.



TM #2

HVAC MATERIALS  
UNIT I

INFORMATION SHEET

I. Terms and definitions associated with HVAC materials

- A. **HVAC** — Heating, ventilation, and air conditioning
- B. **Air conditioning** — Conditioning of the air, including cooling, heating, humidifying, dehumidifying, filtering, and distribution
- C. **ACR copper** — Type of tubing manufactured specifically for air conditioning and refrigeration that is free of contaminants and sealed; measured by outside diameter
- D. **Nominal size copper** — Type of tubing used on water lines, drains, and in other applications, but never in connection with refrigerants; measured by inside diameter
- E. **Flare** — Enlarging the end of a piece of tubing to a 45-degree angle to allow a flared fitting to seal tight against it
- F. **Swage** — Enlarging one end of a piece of tubing so that the end of another tube of the same size will fit into it
- G. **Sweat** — Method of joining copper tubing to copper fittings by soldering
- H. **Hydronic** — System of heating or cooling that involves the transfer of heat by circulating fluid such as water or vapor in a closed system of pipes
- I. **Soldering** — Joining two metals by adhesion of a low melting temperature metal
- J. **Flux** — Mildly corrosive substance applied to a joint prior to soldering to prevent oxidation

II. Types of tubing used in HVAC applications

(NOTE: Copper tubing is the most widely used tubing in this trade.)

- A. Nominal size copper
- B. ACR copper
- C. Aluminum
- D. Steel
- E. Neoprene flexible refrigerant hose



## INFORMATION SHEET

## III. Color coding of copper tubing cartons and tags

(NOTE: The following type letters designate wall thicknesses; they are in descending order from heavy to thin wall.)

- A. Green — Type K
- B. Blue — Type L
- C. Red — Type M
- D. Yellow — Type DWV

## IV. Applications for nominal size copper tubing

(NOTE: Copper tubing sizes used in HVAC run from  $\frac{1}{8}$  inch to over 6 inches, and they are tempered by annealing or hard drawn.)

## A. Type M

- 1. Underground water service
- 2. Water distribution systems
- 3. Chilled water systems
- 4. Hot water heating and low pressure steam
- 5. Ice maker water lines

## B. Type L

- 1. Underground water service where coils are permitted
- 2. Hydronic heating where coils are used
- 3. Water heating or condensate return

## C. Type K

- 1. Wherever severe corrosion conditions exist
- 2. Where self-support is vital

## D. Type DWV

- 1. Drain waste pipe
- 2. Hot water heating where larger than 1  $\frac{1}{4}$  inches are needed



## INFORMATION SHEET

## V. Applications for ACR copper tubing

## A. Air conditioning

1. Suction line
2. Liquid line
3. Evaporator coils
4. Condenser coils
5. Discharge line

## B. Refrigeration

1. Suction line
2. Liquid line
3. Evaporator coils
4. Condenser coils
5. Discharge line

(NOTE: Refrigerant carrying tubing is available in "K," "L," and "M" wall thicknesses. The majority of the ACR tubing is of the "L" wall thickness.)

## VI. Applications for aluminum tubing

## A. Domestic refrigerators

1. Evaporators
2. Suction lines

## B. Central air conditioner condensers

## C. Automotive air conditioner

- |                 |                |
|-----------------|----------------|
| 1. Condensers   | 3. Receivers   |
| 2. Liquid lines | 4. Evaporators |

## VII. Applications for steel tubing

## A. Compression refrigeration

1. Condensers
2. Liquid lines
3. Oil coolers

(NOTE: Steel lines are often used on domestic refrigeration.)

## B. Absorption refrigeration — all refrigerant-carrying components must be steel tubing

## VIII. Applications for neoprene flexible refrigerant hose

- A. Automotive air conditioning
- B. Central air conditioning where complicated bends might be encountered
- C. Units that have a tendency to vibrate excessively



## INFORMATION SHEET

## IX. Tubing fittings

## A. Flared fittings

1. Seal cap

FIGURE 1



2. Flare gasket

FIGURE 2



3. Cross

FIGURE 3



4. Union elbow

FIGURE 4



5. Female elbow

FIGURE 5



6. Reducing union elbow

FIGURE 6



7. Female swivel elbow

FIGURE 7



8. Short nut

FIGURE 8



9. Long nut

FIGURE 9



(NOTE: The short nut is also made with slits or holes for low temperature applications to prevent the nut from loosening due to expansion and contraction. This type of nut is called a frost-free nut.)

10. Cap nut

FIGURE 10



11. Flare cap

FIGURE 11



12. Nut—heavy pattern

FIGURE 12



Figures 1-12 used with permission of Mid-America Vocational Curriculum Consortium, Inc., Stillwater, OK.

## INFORMATION SHEET

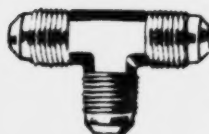
13. Plug

FIGURE 13



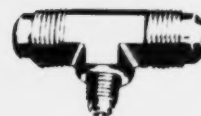
14. Union tee

FIGURE 14



15. Reducing tee—small to large

FIGURE 15



16. Reducing tee—large to small

FIGURE 16



17. Union

FIGURE 17



18. Female connector

FIGURE 18



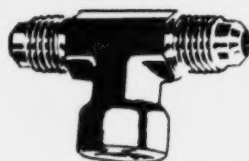
19. Female union

FIGURE 19



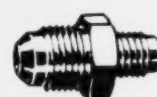
20. Tee—female to male

FIGURE 20



21. Reducing union

FIGURE 21



22. Reducer

FIGURE 22



23. Swivel

FIGURE 23



Figures 13-23 used with permission of Mid-America Vocational Curriculum Consortium, Inc., Stillwater, OK.



## INFORMATION SHEET

## B. Flare to pipe fittings

1. Male elbow

FIGURE 24



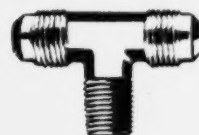
2. 45-degree male elbow

FIGURE 25



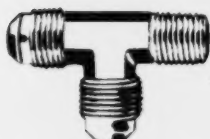
3. Male branch tree

FIGURE 26



4. Male run tee

FIGURE 27



5. Female coupling

FIGURE 28



6. Male connector

FIGURE 29



## C. Compression fittings

1. Sleeve (Ferrule)

FIGURE 30



2. Nut

FIGURE 31



3. Union

FIGURE 32



4. Compression to pipe union

FIGURE 33



5. Union elbow

FIGURE 34



6. Union tee

FIGURE 35



7. Female connector

FIGURE 36



8. Female elbow

FIGURE 37



Figures 24-37 used with permission of Mid-America Vocational Curriculum Consortium, Inc., Stillwater, OK.

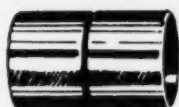
## INFORMATION SHEET

(NOTE: This female elbow is not generally used in refrigerant lines.)

## D. Sweat fittings

1. Coupling

FIGURE 38



2. Coupling reducer

FIGURE 39



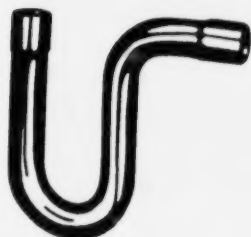
3. Return bend

FIGURE 40



4. Suction-line trap

FIGURE 41



5. 90-degree elbow

FIGURE 42



6. 45-degree elbow

FIGURE 43



7. Street elbow

FIGURE 44



8. Cap

FIGURE 45



9. Tee

FIGURE 46



(NOTE: Sweat-type elbows are available with a long or short bend radius.)

10. Sweat to pipe

FIGURE 47



11. Sweat to flare

FIGURE 48



12. Sweat to flare swivel

FIGURE 49



Figures 38-49 used with permission of Mid-America Vocational Curriculum Consortium, Inc., Stillwater, OK.

## INFORMATION SHEET

## X. Flexible refrigerant hose and quick-connect fittings

## A. Hose fittings

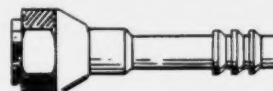
1. Male flare

FIGURE 50



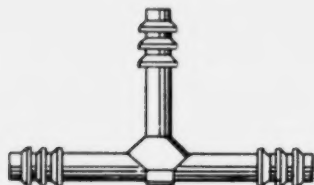
2. Female flare

FIGURE 51



3. Tee splice

FIGURE 52



4. Straight splice

FIGURE 53

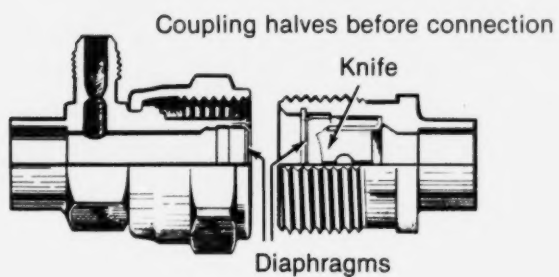


(NOTE: Straight splice fittings are primarily used on automotive air conditioning.)

## B. Quick-connect fittings

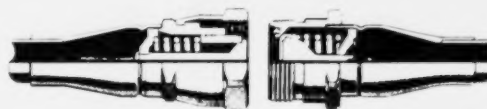
1. Cutter type

FIGURE 54



2. Spring-loaded seal

FIGURE 55



Figures 50-55 Used with permission of Mid-America Vocational Curriculum Consortium, Inc., Stillwater, OK.

## INFORMATION SHEET

## 3. Compression type

FIGURE 56



Figure 56 used with permission of Mid-America Vocational Curriculum Consortium, Inc., Stillwater, OK.

## XI. Types of pipe used in HVAC and their applications

## A. Black iron pipe

1. Natural gas lines
2. Liquified petroleum gas lines
3. Ammonia lines
4. Compressed air lines
5. Hydronic heat and steam lines

## B. Galvanized iron pipe

1. Ice maker water lines
2. Water supply lines
3. Water-cooled condenser supply and return lines
4. Condensate lines and drains

## C. PVC and flexible plastic pipe

1. Water supply lines
2. Underground gas lines
3. Condensate lines and drains
4. Chilled-water supply and return lines

(NOTE: Local codes should be checked before using plastic pipes.)



## INFORMATION SHEET

## XII. Pipe fittings

## A. Black and galvanized iron fittings

1. 90-degree ell

FIGURE 57



2. Tee

FIGURE 58



3. 45-degree ell

FIGURE 59



4. 90-degree street ell

FIGURE 60



5. Union

FIGURE 61



6. Coupling

FIGURE 62



(NOTE: When connecting galvanized pipe to any other type of pipe, a special union must be used to prevent a corrosive action. This union is called an insulated union.)

7. Reducer

FIGURE 63



8. Flange

FIGURE 64



9. Bushing

FIGURE 65



10. Cap

FIGURE 66



11. Plug

FIGURE 67



12. Nipple

FIGURE 68



Figures 57-68 used with permission of Mid-America Vocational Curriculum Consortium, Inc., Stillwater, OK.

## INFORMATION SHEET

13. Gas cock

FIGURE 69



## B. Brass fittings

1. Nipple

FIGURE 70



2. 90-degree ell

FIGURE 71



3. Street ell

FIGURE 72



4. Tee

FIGURE 73



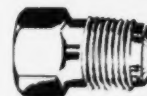
5. Male pipe to male flare

FIGURE 74



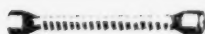
6. Female pipe to male flare

FIGURE 75



7. Flexible gas connector

FIGURE 76



8. Plug

FIGURE 77



9. Bushing

FIGURE 78



Figures 69-78 used with permission of Mid-America Vocational Curriculum Consortium, Inc., Stillwater, OK.



## INFORMATION SHEET

10. Two-way shut-off valve

FIGURE 79



11. Three-way shut-off valve

FIGURE 80



12. Saddle valve

FIGURE 81



## C. Flexible plastic pipe

1. Insert tee

FIGURE 82



2. Insert 90-degree ell

FIGURE 83



3. Insert male adapter

FIGURE 84



4. Insert male steel adapter

FIGURE 85



5. Insert coupling

FIGURE 86



6. Clamp

FIGURE 87



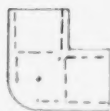
Figures 79-87 used with permission of Mid-America Vocational Curriculum Consortium, Inc., Stillwater, OK.

## INFORMATION SHEET

## D. PVC fittings

1. 90-degree ell

FIGURE 88



2. 45-degree ell

FIGURE 89



3. Tee

FIGURE 90



4. Male adapter

FIGURE 91



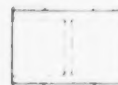
5. Female adapter

FIGURE 92



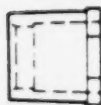
6. Coupling

FIGURE 93



7. Bushing

FIGURE 94



8. Cap

FIGURE 95



9. 90-degree ell (PVC to pipe)

FIGURE 96



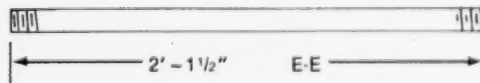
## XIII. Methods used to measure pipe

## A. End to end

1. Straight length of pipe
2. Measure pipe without fittings

## EXAMPLE 1:

FIGURE 97



Figures 88-97 used with permission of Mid-America Vocational Curriculum Consortium, Inc., Stillwater, OK.



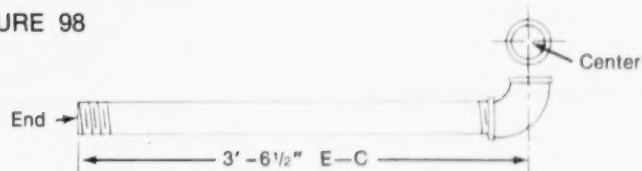
## INFORMATION SHEET

## B. End to center

1. Straight length of pipe
2. Tighten a fitting on one end
3. Measure from end of pipe to center of fitting

## EXAMPLE 2:

FIGURE 98

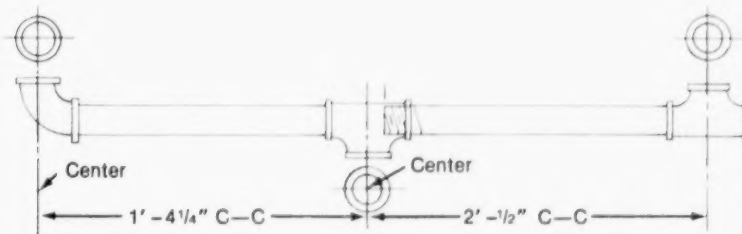


## C. Center to center

1. Straight length of pipe
2. Tighten fittings on each end
3. Measure from center of one fitting to center of the other fitting

## EXAMPLE 3:

FIGURE 99



## XIV. Materials needed to join pipe

## A. Soft solder

1. 50-50 solder — 50% tin, 50% lead
2. 95-5 solder — 95% tin, 5% antimony
3. 40-60 solder — 40% tin, 60% lead
4. 97-3 solder — 97% tin, 3% silver

Figures 98-99 used with permission of Mid-America Vocational Curriculum Consortium, Inc., Stillwater, OK.

## INFORMATION SHEET

## B. Flux for soft solder

1. Paste flux
2. Liquid self cleaning flux

## C. Silver brazing alloy (hard solder)

1. AWS number BAg-1 — 45% silver, 15% copper, 16% zinc, 24% cadmium
2. AWS number BCuP-5 — 15% silver, 80% copper, 5% phosphorus
3. AWS number BCuP-3 — 5% silver, 89% copper, 6% phosphorus

(NOTE: BCuP-5 and BCuP-3 work at approximately the same temperature. BCuP-5 is the preferred alloy to use due to the higher silver content which gives added strength to the solder joint. On copper to copper joints these two alloys may be used without flux.)

## D. Aluminum soft solder

## F. Welding flux

## H. Teflon tape

## E. Aluminum brazing rod

## G. Pipe dope

(NOTE: For information on welding see "Introduction to Welding" in this series.)

## XV. Types of air-treatment units

## A. Cooling systems

1. Central air conditioner
2. Window air conditioner

## B. Heating systems

1. Electronic duct heater
2. Electric furnace
3. Oil furnace
4. Gas furnace
5. Heat pump
6. Hydronic system

## C. Humidifiers

1. Pan type
2. Atomizing type
3. Wetted element type

## D. Dehumidifier

## E. Filter — electronic



## INFORMATION SHEET

## F. Air movers

1. Exhaust fan
2. Ceiling fan

## XVI. Basic components of a cooling system

- |                            |                    |
|----------------------------|--------------------|
| A. Suction line            | D. Compressor      |
| B. Evaporator              | E. Condenser       |
| C. Liquid refrigerant line | F. Metering device |

## XVII. Major components in furnace construction

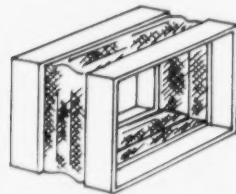
- A. Combustion chamber (except electric)
- B. Burner assembly
- C. Flue (except electric)
- D. Heat exchanger or boiler
- E. Draft diverter or damper (except electric)
- F. Blower assembly
- G. Air filter
- H. Cabinet

## XVIII. Commonly used HVAC duct fittings

(NOTE: Ducts and duct fittings are made from various types of materials such as galvanized steel, black steel, copper, stainless steel, aluminum transite, PVC, fibrous glass. Flexible ducts and duct fittings are made from a heavy canvas material. See example.)

EXAMPLE:

FIGURE 100





## INFORMATION SHEET

## A. Plenum (bonnet)

## EXAMPLES:

FIGURE 101

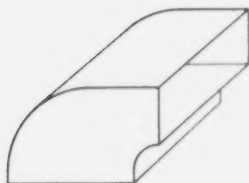


FIGURE 102

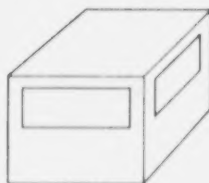


FIGURE 103



(NOTE: The plenum is the first fitting from the air distribution system.)

## B. Plenum takeoff

## EXAMPLES:

FIGURE 104

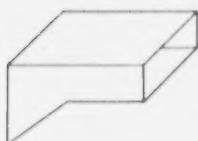
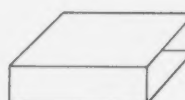


FIGURE 105



Straight transition

Straight rectangle

(NOTE: Takeoff fittings are attached directly to the plenum and lead the air into the trunkline.)

## C. Trunkline

## EXAMPLES:

FIGURE 106



FIGURE 107



FIGURE 108



Square elbow

Rectangle elbow

Offset

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## INFORMATION SHEET

FIGURE 109

Square-to-round  
transition

FIGURE 110

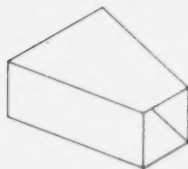
Square-to-rectangle  
transition

FIGURE 111



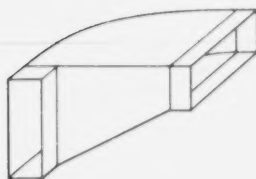
Y-branch

(NOTE: Trunkline connects to the trunk takeoff which carries the air to the branches. Trunkline fittings can be round or rectangular and vary in size.)

## D. Trunk duct takeoff

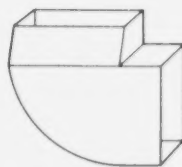
## EXAMPLE:

FIGURE 112



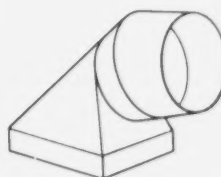
Side takeoff

FIGURE 113



Top takeoff

FIGURE 114



Square-to-round transition

(NOTE: Trunk duct takeoffs are connected to the branch lines which carry the air to the boots. These fittings can be round or rectangular and or made as top takeoff or side takeoff in various sizes.)

## E. Boots

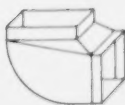
## EXAMPLES:

FIGURE 115



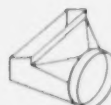
Square to wall

FIGURE 116



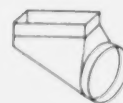
Square to floor

FIGURE 117



Round to wall

FIGURE 118



Round to floor

(NOTE: Boot fittings direct the air flow from the branch line to the registers or to the stacks in the walls. These fittings can also be round to rectangular or square to rectangular and are available in various register sizes.)

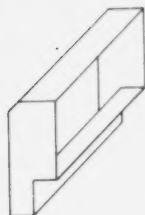
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## INFORMATION SHEET

## F. Stackheads

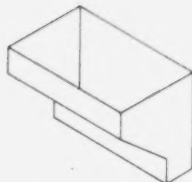
## EXAMPLES:

FIGURE 119



Wall

FIGURE 120



Floor

FIGURE 121



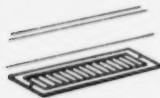
Baseboard

(NOTE: These fittings lead the air from the stacks in the walls to the registers; these are also available in various stack and register sizes.)

## XIX. Common types of registers and diffusers

## A. Floor register

FIGURE 122



## B. Baseboard register

FIGURE 123



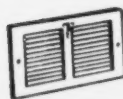
## C. Low sidewall register

FIGURE 124



## D. High sidewall register

FIGURE 125



## E. Ceiling panel register

FIGURE 126



## F. Wall diffuser

FIGURE 127



## G. Ceiling diffuser

FIGURE 128



## H. Cast iron radiator

FIGURE 129



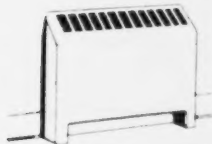
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Figure 129 used with permission of NHAW Home Study Institute, Columbia, Ohio.



## INFORMATION SHEET

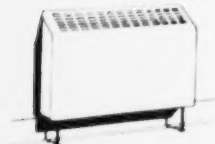
## I. Convactor radiators

FIGURE 130



Standing

FIGURE 131



Wall Hung

Figures 130-131 from Air-Conditioning and Refrigeration Institute, REFRIGERATION AND AIR-CONDITIONING, © 1979, p.541. Reprinted by permission of Prentice Hall, Inc., Englewood Cliffs, New Jersey.

## XX. HVAC hangers and supports

## A. Duct hangers

- |               |                                                           |
|---------------|-----------------------------------------------------------|
| 1. Strap iron | 3. Metal rods                                             |
| 2. Angle iron | 4. Combinations of strap iron, angle iron, and metal rods |

## B. Pipe hangers

- |           |              |
|-----------|--------------|
| 1. Clevis | 3. Pipe roll |
| 2. Ring   | 4. Vertical  |

## C. Supports

- |                 |                     |
|-----------------|---------------------|
| 1. Anchor chair | 3. C-clamp          |
| 2. Beam clamp   | 4. Horizontal clamp |

# HVAC MATERIALS UNIT I

## TEST

NAME \_\_\_\_\_

SCORE \_\_\_\_\_

1. Match terms associated with HVAC materials to their correct definitions. Write the correct numbers in the blanks.

- |                                                                                                                                                               |                             |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------|
| _____a. Heating, ventilation, and air conditioning                                                                                                            | 1. Nominal size..<br>copper |
| _____b. Conditioning of the air, including cooling, heating, humidifying, dehumidifying, filtering, and distribution                                          | 2. Sweat                    |
|                                                                                                                                                               | 3. Flux                     |
| _____c. Type of tubing manufactured specifically for air conditioning and refrigeration that is free of contaminants and sealed; measured by outside diameter | 4. HVAC                     |
|                                                                                                                                                               | 5. Hydronic                 |
|                                                                                                                                                               | 6. Flare                    |
| _____d. Type of tubing used on water lines, drains, and in other applications, but never in connection with refrigerants; measured by inside diameter         | 7. Air conditioning         |
|                                                                                                                                                               | 8. Soldering                |
| _____e. Enlarging the end of a piece of tubing to a 45-degree angle to allow a flared fitting to seal tight against it                                        | 9. Swage                    |
|                                                                                                                                                               | 10. ACR copper              |
| _____f. Enlarging one end of a piece of tubing so that the end of another tube of the same size will fit into it                                              |                             |
| _____g. Method of joining copper tubing to copper fittings by soldering                                                                                       |                             |
| _____h. System of heating or cooling that involves the transfer of heat by circulating fluid such as water or vapor in a closed system of pipes               |                             |
| _____i. Joining two metals by adhesion of a low melting temperature metal                                                                                     |                             |
| _____j. Mildly corrosive substance applied to a joint prior to soldering to prevent oxidation                                                                 |                             |



## TEST

2. Select from the following list types of tubing used in HVAC applications. Write an "X" in the blank before each correct answer.

- |                              |                                                |
|------------------------------|------------------------------------------------|
| _____ a. Steel               | _____ e. Lead                                  |
| _____ b. Brass               | _____ f. Neoprene flexible<br>refrigerant hose |
| _____ c. Nominal size copper | _____ g. PVC                                   |
| _____ d. Aluminum            | _____ h. ACR copper                            |

3. Match the color coding of cartons and tags with the correct type of copper tubing. Write the correct types in the blanks.

- |                 |          |
|-----------------|----------|
| _____ a. Green  | Type M   |
| _____ b. Red    | Type DWV |
| _____ c. Blue   | Type K   |
| _____ d. Yellow | Type L   |

4. State two applications for each type of nominal size copper tubing.

a. Type M

1. \_\_\_\_\_
2. \_\_\_\_\_

b. Type L

1. \_\_\_\_\_
2. \_\_\_\_\_

c. Type K

1. \_\_\_\_\_
2. \_\_\_\_\_

d. Type DWV

1. \_\_\_\_\_
2. \_\_\_\_\_

5. State three applications for ACR copper tubing in air conditioning or refrigeration.

- a. \_\_\_\_\_
- b. \_\_\_\_\_
- c. \_\_\_\_\_

## TEST

6. State three applications for aluminium tubing.

- a. \_\_\_\_\_
- b. \_\_\_\_\_
- c. \_\_\_\_\_

7. State two applications for steel tubing.

- a. \_\_\_\_\_
- b. \_\_\_\_\_

8. State two applications for neoprene flexible refrigerant hose.

- a. \_\_\_\_\_
- b. \_\_\_\_\_

9. Identify tubing fittings illustrated below. Write their correct names in the blanks.

Seal cap  
Union elbow  
Cap nut  
Reducer  
Reducing union  
Long nut

Flare gasket  
Female elbow  
Union tee  
Female union  
Reducing tee—  
large to small

Cross  
Plug  
Union  
Swivel  
Nut—heavy pattern  
Female connector

Reducing tee—  
small to large  
Reducing union elbow  
Female swivel elbow  
Short nut  
Tee—female to male  
Flare cap

A. Flared fittings



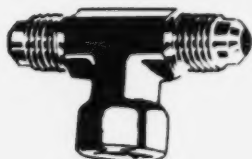
1. \_\_\_\_\_



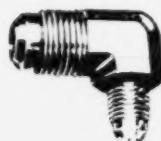
2. \_\_\_\_\_



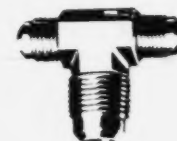
3. \_\_\_\_\_



4. \_\_\_\_\_



5. \_\_\_\_\_



6. \_\_\_\_\_



## TEST



7. \_\_\_\_\_



8. \_\_\_\_\_



9. \_\_\_\_\_



10. \_\_\_\_\_



11. \_\_\_\_\_



12. \_\_\_\_\_



13. \_\_\_\_\_



14. \_\_\_\_\_



15. \_\_\_\_\_



16. \_\_\_\_\_



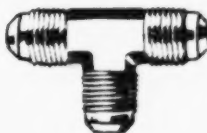
17. \_\_\_\_\_



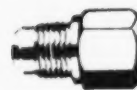
18. \_\_\_\_\_



19. \_\_\_\_\_



20. \_\_\_\_\_



21. \_\_\_\_\_



22. \_\_\_\_\_



23. \_\_\_\_\_



## TEST

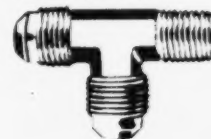
## B. Flare-to-pipe fittings

Male branch tee  
Male run tee

1. \_\_\_\_\_

Male connector  
45-degree male elbow

2. \_\_\_\_\_

Male elbow  
Female coupling

3. \_\_\_\_\_



4. \_\_\_\_\_



5. \_\_\_\_\_



6. \_\_\_\_\_

## C. Compression fittings

Union  
Sleeve (Ferrule)  
Female connector

1. \_\_\_\_\_

Union tee  
Nut

2. \_\_\_\_\_

Female elbow  
Union elbow

3. \_\_\_\_\_

Compression to  
pipe union

4. \_\_\_\_\_



5. \_\_\_\_\_



6. \_\_\_\_\_



7. \_\_\_\_\_



8. \_\_\_\_\_

## TEST

## D. Sweat fittings

Sweat to flare  
Sweat to flare  
swivel  
45-degree elbow

Street elbow  
90-degree elbow  
Suction-line trap

Return bend  
Coupling reducer  
Coupling

Sweat to pipe  
Cap  
Tee



1. \_\_\_\_\_

2. \_\_\_\_\_

3. \_\_\_\_\_



4. \_\_\_\_\_

5. \_\_\_\_\_

6. \_\_\_\_\_



7. \_\_\_\_\_

8. \_\_\_\_\_

9. \_\_\_\_\_



10. \_\_\_\_\_

11. \_\_\_\_\_

12. \_\_\_\_\_

10. Identify flexible refrigerant hose and disconnect fittings illustrated below. Write their correct names in the blanks.

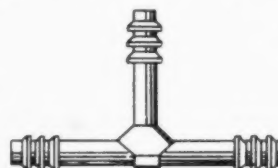
Male flare

Tee splice

Straight splice

Female flare

## A. Hose fittings



1. \_\_\_\_\_

2. \_\_\_\_\_

## TEST



3. \_\_\_\_\_



4. \_\_\_\_\_

## B. Quick-connect fittings

Spring-loaded seal

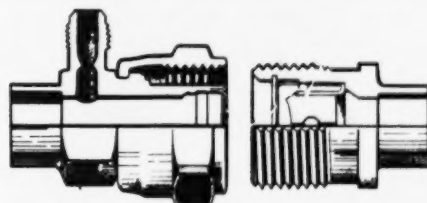
Compression type

Cutter type



1. \_\_\_\_\_

2. \_\_\_\_\_



3. \_\_\_\_\_

11. Match types of pipe used in HVAC to their applications. Write a "B" in the blanks pertaining to black iron pipe, a "G" in the blanks pertaining to galvanized iron pipe and "PVC" in the blanks pertaining to PVC and flexible plastic pipe. You may have more than one answer for each blank.

\_\_\_\_ a. Water supply lines

\_\_\_\_ g. Hydronic heat and steam lines

\_\_\_\_ b. Ammonia lines

\_\_\_\_ h. Water-cooled condenser supply and return lines

\_\_\_\_ c. Natural gas lines

\_\_\_\_ i. Chilled-water supply and return lines

\_\_\_\_ d. Underground gas lines

\_\_\_\_ j. Compressed-air lines

\_\_\_\_ e. Liquefied petroleum gas lines

\_\_\_\_ k. Condensate lines and drains



## TEST

12. Identify pipe fittings illustrated below. Write their correct names in the blanks.

Union  
90-degree ell  
Reducer  
Flange

90-degree street ell  
Coupling  
Plug

45-degree ell  
Tee  
Nipple

Bushing  
Gas cock  
Cap

A. Black and galvanized iron fittings



1. \_\_\_\_\_



2. \_\_\_\_\_



3. \_\_\_\_\_



4. \_\_\_\_\_



5. \_\_\_\_\_



6. \_\_\_\_\_



7. \_\_\_\_\_



8. \_\_\_\_\_



9. \_\_\_\_\_



10. \_\_\_\_\_



11. \_\_\_\_\_



12. \_\_\_\_\_



13. \_\_\_\_\_

## TEST

## B. Brass fittings

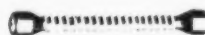
Flexible gas connector  
Bushing  
Street ell  
Tee

Male pipe to male flare  
Three-way shut-off valve  
Two-way shut-off valve  
90-degree ell

Saddle valve  
Female pipe to male flare  
Nipple  
Plug



1. \_\_\_\_\_ 2. \_\_\_\_\_ 3. \_\_\_\_\_



4. \_\_\_\_\_ 5. \_\_\_\_\_ 6. \_\_\_\_\_



7. \_\_\_\_\_ 8. \_\_\_\_\_ 9. \_\_\_\_\_



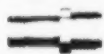
10. \_\_\_\_\_ 11. \_\_\_\_\_ 12. \_\_\_\_\_

## C. Flexible plastic pipe

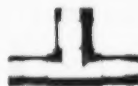
Insert male adapter  
Insert 90-degree ell

Insert coupling  
Insert tee

Insert male steel adapter  
Clamp



1. \_\_\_\_\_ 2. \_\_\_\_\_ 3. \_\_\_\_\_



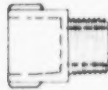
4. \_\_\_\_\_ 5. \_\_\_\_\_ 6. \_\_\_\_\_



## TEST

## D. PVC fittings

90-degree ell  
(PVC to pipe)  
Tee



1. \_\_\_\_\_

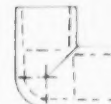
Female adapter  
Female adapter  
90-degree ell



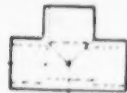
2. \_\_\_\_\_

Bushing  
Male adapter

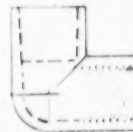
45-degree ell  
Cap



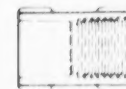
3. \_\_\_\_\_



4. \_\_\_\_\_



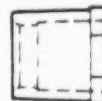
5. \_\_\_\_\_



6. \_\_\_\_\_



7. \_\_\_\_\_



8. \_\_\_\_\_



9. \_\_\_\_\_

13. State three methods used to measure pipe.

a. \_\_\_\_\_

b. \_\_\_\_\_

c. \_\_\_\_\_

14. Select from the following list materials needed to join pipe. Write an "X" in the blank before each correct answer.

\_\_\_\_ a. Aluminum brazing rod

\_\_\_\_ e. Soft solder

\_\_\_\_ b. Silver brazing alloy (hard solder)

\_\_\_\_ f. Copper phosphorus

\_\_\_\_ c. Flux for aluminum solder

\_\_\_\_ g. Flux for soft solder

\_\_\_\_ d. Teflon tape

\_\_\_\_ h. Pipe dope

\_\_\_\_ i. Welding flux

## TEST

15. Name the six types of air-treatment units.

a. \_\_\_\_\_ d. \_\_\_\_\_  
 b. \_\_\_\_\_ e. \_\_\_\_\_  
 c. \_\_\_\_\_ f. \_\_\_\_\_

16. Select from the following list the basic components of a cooling system. Write an "X" in the blank before each correct answer.

\_\_\_\_ a. Condenser  
 \_\_\_\_ b. Evaporator  
 \_\_\_\_ c. Metering device  
 \_\_\_\_ d. Compressor  
 \_\_\_\_ e. Filter  
 \_\_\_\_ f. Suction line  
 \_\_\_\_ g. Exhaust fan  
 \_\_\_\_ h. Liquid refrigerant line

17. Select from the following list the major components in furnace construction. Write an "X" in the blank before each correct answer.

\_\_\_\_ a. Flue (except electric)  
 \_\_\_\_ b. Draft diverter or damper (except electric)  
 \_\_\_\_ c. Filter  
 \_\_\_\_ d. Metering device  
 \_\_\_\_ e. Blower assembly  
 \_\_\_\_ f. Cabinet  
 \_\_\_\_ g. Burner assembly  
 \_\_\_\_ h. Condenser  
 \_\_\_\_ i. Combustion chamber (except electric)  
 \_\_\_\_ j. Heat exchanger or boiler

18. Identify the commonly used HVAC duct fittings illustrated below. Write their correct names in the blanks.

**Plenum (bonnet)  
Stackheads**



a. \_\_\_\_\_

**Trunkline  
Plenum takeoff**

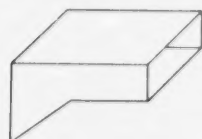


b. \_\_\_\_\_

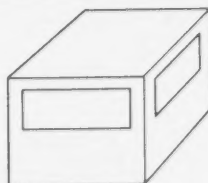
**Trunk duct takeoff  
Boots**



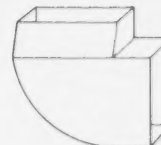
c. \_\_\_\_\_



d. \_\_\_\_\_



e. \_\_\_\_\_



f. \_\_\_\_\_



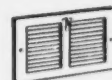
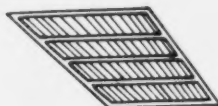
## TEST

19. Identify the common types of registers and diffusers illustrated below. Write their correct names in the blanks.

Baseboard register  
Ceiling diffuser  
Floor register

High sidewall register  
Low sidewall register  
Convactor radiator

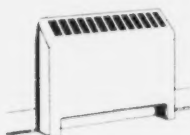
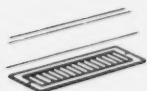
Wall diffuser  
Ceiling panel  
Cast iron radiator



a. \_\_\_\_\_ b. \_\_\_\_\_ c. \_\_\_\_\_



d. \_\_\_\_\_ e. \_\_\_\_\_ f. \_\_\_\_\_



g. \_\_\_\_\_ h. \_\_\_\_\_ i. \_\_\_\_\_

20. Select from the following list types of HVAC hangers and supports. Write "D" in the blanks before duct hangers, "P" for pipe hangers, and "S" for supports.

\_\_\_\_\_ a. Ring

\_\_\_\_\_ g. Anchor chair

\_\_\_\_\_ b. C-clamp

\_\_\_\_\_ h. Pipe roll

\_\_\_\_\_ c. Metal rods

\_\_\_\_\_ i. Angle iron

\_\_\_\_\_ d. Combinations of strap iron, angle iron, and metal rods

\_\_\_\_\_ j. Strap iron

\_\_\_\_\_ e. Horizontal clamp

\_\_\_\_\_ k. Clevis

\_\_\_\_\_ f. Vertical

\_\_\_\_\_ l. Beam clamp



HVAC MATERIALS  
UNIT I

## ANSWERS TO TEST

1. a. 4                      c. 10                      e. 6                      g. 2                      i. 8  
   b. 7                      d. 1                      f. 9                      h. 5                      j. 3
2. a, c, d, f, h
3. a. K                      c. L  
   b. M                      d. DWV
4. Answer should include any two of the following for each type.
  - A. Type M
    1. Underground water source
    2. Water distribution systems
    3. Chilled water systems
    4. Hot water heating and low pressure steam
    5. Ice maker water lines
  - B. Type L
    1. Underground water service where coils are permitted
    2. Hydronic heating where coils are used
    3. Water heating or condensate return
  - C. Type K
    1. Whenever severe corrosion conditions exist
    2. Where self-support is vital
  - D. Type DWV
    1. Drain waste pipe
    2. Hot water heating where larger than 1 1/4 inches are needed
5. Answer should include any three of the following.
  - a. Suction line                      d. Condenser coils
  - b. Liquid line                      e. Discharge line
  - c. Evaporator coils
6. Answer should include any three of the following.
  - a. Evaporators on domestic refrigerators
  - b. Suction lines on domestic refrigerators
  - c. Central air conditioner condensers
  - d. Condensers for automobile air conditioners
  - e. Liquid lines for automobile air conditioners
  - f. Receivers for automobile air conditioners
  - g. Evaporators for automobile air conditioners



## ANSWERS TO TEST

7. Answer should include any two of the following.
- Compression refrigeration condensers
  - Compression refrigeration liquid lines
  - Compression refrigeration oil coolers
  - All refrigerant carrying components on absorption refrigeration
8. Answer should include any two of the following.
- Automotive air conditioning
  - Central air conditioning where complicated bends might be encountered
  - Units that have a tendency to vibrate excessively
9. A. Flared fittings
- |                                 |                                 |
|---------------------------------|---------------------------------|
| 1. Union                        | 12. Female elbow                |
| 2. Female union                 | 13. Short nut                   |
| 3. Long nut                     | 14. Reducing tee—small to large |
| 4. Tee—female to male           | 15. Reducer                     |
| 5. Reducing union elbow         | 16. Nut—heavy pattern           |
| 6. Reducing tee —large to small | 17. Reducing union              |
| 7. Female connector             | 18. Cross                       |
| 8. Seal cap                     | 19. Flare gasket                |
| 9. Flare cap                    | 20. Union tee                   |
| 10. Female swivel elbow         | 21. Plug                        |
| 11. Swivel                      | 22. Union elbow                 |
|                                 | 23. Cap nut                     |
- B. Flare-to-pipe fittings
- |                    |                    |                         |
|--------------------|--------------------|-------------------------|
| 1. Male elbow      | 3. Male run tee    | 5. Male connector       |
| 2. Female coupling | 4. Male branch tee | 6. 45-degree male elbow |
- C. Compression fittings
- |                              |                     |
|------------------------------|---------------------|
| 1. Compression to pipe union | 5. Nut              |
| 2. Female elbow              | 6. Union            |
| 3. Union tee                 | 7. Sleeve (Ferrule) |
| 4. Female connector          | 8. Union elbow      |
- D. Sweat fittings
- |                    |                          |
|--------------------|--------------------------|
| 1. Sweat to flare  | 7. Return bend           |
| 2. Cap             | 8. Sweat to flare swivel |
| 3. Sweat to pipe   | 9. 45-degree elbow       |
| 4. 90-degree elbow | 10. Coupling reducer     |
| 5. Tee             | 11. Street elbow         |
| 6. Coupling        | 12. Suction-line trap    |

## ANSWERS TO TEST

10. A. Hose fittings  
     1. Straight splice  
     2. Tee splice  
     3. Female flare  
     4. Male flare
- B. Quick connect fittings  
     1. Spring loaded seal  
     2. Compression type  
     3. Cutter type
11. a. G-PVC      d. PVC      g. B      J. B  
     b. B          e. B      h. G      k. G-PVC  
     c. B          f. G      i. PVC
12. A. Black and galvanized iron fittings  
     1. Plug      6. Cap      11. Reducer  
     2. Union     7. Coupling      12. Bushing  
     3. Nipple    8. Flange      13. 45-degree ell  
     4. 90-degree ell    9. 90-degree street ell  
     5. Gas cock      10. Tee
- B. Brass fittings  
     1. Three-way shut-off valve      7. Female pipe to male flare  
     2. Saddle valve      8. Nipple  
     3. Two-way shut-off valve      9. Plug  
     4. Bushing      10. Tee  
     5. Flexible gas connector      11. Street ell  
     6. Male pipe to male flare      12. 90-degree ell
- C. Flexible plastic pipe  
     1. Insert male adapter      4. Insert 90-degree ell  
     2. Insert male steel adapter      5. Insert tee  
     3. Clamp      6. Insert coupling
- D. PVC fittings  
     1. Male adapter      5. 90-degree ell      8. Bushing  
     2. Cap      (PVC to pipe)      9. Coupling  
     3. 90-degree ell      6. Female adapter  
     4. Tee      7. 45-degree ell



## ANSWERS TO TEST

13. Answer should include the following.

- a. End to end
- b. End to center
- c. Center to center

14. a, b, d, e, g, h, i

15. Answer should include the following.

- |                    |                      |
|--------------------|----------------------|
| a. Cooling systems | e. Dehumidifier      |
| b. Heating systems | f. Filter—electronic |
| c. Humidifiers     | g. Air movers        |

16. a, b, c, d, f, h

17. a, b, c, e, f, g, i, j

- |                  |                       |
|------------------|-----------------------|
| 18. a. Trunkline | d. Plenum takeoff     |
| b. Stackhead     | e. Plenum (bonnet)    |
| c. Boots         | f. Trunk duct takeoff |

- |                              |                       |
|------------------------------|-----------------------|
| 19. a. Low sidewall register | e. Ceiling diffuser   |
| b. Ceiling panel             | f. Baseboard register |
| c. High sidewall register    | g. Floor register     |
| d. Wall diffuser             | h. Convactor radiator |
|                              | i. Cast iron radiator |

- |          |      |      |
|----------|------|------|
| 20. a. P | e. S | i. D |
| b. S     | f. P | j. D |
| c. D     | g. S | k. P |
| d. D     | h. P | l. S |

## HVAC TOOLS UNIT II

### UNIT OBJECTIVE

After completing this unit, the student should be able to state guidelines for care and safe use of HVAC tools. The student should also be able to identify tools used in HVAC. The student will show this knowledge by completing the unit test with a minimum score of 80 percent.

### SPECIFIC OBJECTIVES

After completing this unit, the student should be able to

1. Match terms associated with HVAC tools to their correct definitions.
2. State guidelines for care and safe use of HVAC tools.
3. Identify common hand tools used in HVAC.
4. Identify accessory tools used in HVAC.
5. Identify specialty tools used in HVAC.
6. Read a circumference rule.
7. Use inside and outside calipers.
8. Read micrometer settings.



HVAC TOOLS  
UNIT II

## SUGGESTED ACTIVITIES

## I. Unit contents

- A. Objective sheet
- B. Suggested activities
- C. Information sheet
- D. Assignment sheets
  - 1. Assignment Sheet #1 — Read the Circumference Rule
  - 2. Assignment Sheet #2 — Use the Inside and Outside Calipers
  - 3. Assignment Sheet #3 — Read the Micrometer Settings
- E. Answers to assignment sheets
- F. Test
- G. Answers to test

## II. Instructor's guide

- A. Review unit and plan presentation.
- B. Obtain materials to supplement unit.
  - 1. Film strips and slide programs
    - a. *Basic Mechanical Refrigeration Cycle*. Booklet and slides. Available from local Bryant distributor or branch or write to BDP company, Division of Carrier Corp., Training and Dealer Development, 7310 West Morris Street, Indianapolis, Indiana 46231.
    - b. *Be Compressor Wise*. Booklet and slides. Available from Carrier Air Conditioning, Carrier Parkway, P.O. Box 4808, Syracuse, New York 13221.
    - c. *Capturing Contaminants*. Filmstrip/Cassette. Available through authorized Sporlan wholesaler or write to Sporlan Valve Company, 7525 Sussex Avenue, St. Louis, Missouri 63143.
    - d. *Cleanout After Burnout*. Booklet and slides. Available from Carrier Air Conditioning, Carrier Parkway, P.O. Box 4808, Syracuse, New York 13221.



## SUGGESTED ACTIVITIES

- e. *Job Skills* — Filmstrip series. Available from Photocom Productions, P.O. Box 3135, Pismo Beach, California 93449.
- f. *Safety in Handling Refrigerants*. Slide/Cassette/Booklet. Available from DuPont de Numours and Co., Inc., Freon Products Division, Sales Support, Chestnut Run, Wilmington, Delaware 19898.

## 2. Books and publications

(NOTE: When ordering books, catalogs, publications, etc., always request the newest editions.)

- a. *Modern Refrigeration and Air Conditioning*. 1975. Available from The Goodheart-Wilcox Company, Inc., South Holland, Illinois.
- b. *Modern Air Conditioning Practice*. 2nd ed. 1974. Available from McGraw-Hill Book Company, New York.
- c. *Air Conditioning and Refrigeration Fundamentals*. 1984. This book covers orientation, safety, tools, tubing and pipe, soldering and welding, basic compression refrigeration and refrigerant system servicing. Available from Mid-America Vocational Curriculum Instructional Consortium, Inc., 1500 West Seventh Avenue, Stillwater, Oklahoma 74074.
- d. *Air Conditioning and Refrigeration, Book III and Book IV*. 1981. These books cover job orientation, applying for a job, customer relations, business management, psychrometrics, residential heat loss and heat gain, duct design and sizing, air treatment, residential systems, gas furnaces, electrical heating systems, residential cooling systems, heat pump systems, balance points and hydronics. Available from Mid-America Vocational Curriculum Instructional Consortium, Inc., 1500 West Seventh Avenue, Stillwater, Oklahoma 74074.

## 3. Tool and equipment catalogs from manufacturers

## 4. Samples of tools and equipment

## 5. Competency profiles

(NOTE: A master of the competency profile for this book is provided at the front of the instructor edition. You may duplicate the profile and distribute it to students as needed.)

## C. Introduce unit to students

- Have students review tool catalogs; discuss the various tools, pointing out the importance of buying good grades of tools. Tell students that quality, not price should be their main concern when purchasing tools.

## SUGGESTED ACTIVITIES

- Show film strips and slides on HVAC.
- D. Provide students with objective sheet.
- E. Discuss unit and specific objectives.
- F. Provide students with information and assignment sheets.
- G. Discuss information and assignment sheets.
1. Use Information Sheet, Section I, to discuss terms and definitions associated with HVAC tools.
    - Show examples or illustrations of appropriate terms.
    - Explain the importance of knowing terms and definitions.
  2. Use Information Sheet, Section II, to discuss guidelines for care and safe use of tools and equipment.
    - Demonstrate to the students how to sharpen, clean, and care for tools.
    - Show students the storage area and demonstrate how to store tools and equipment properly.
    - Outline your tool management policy for shop and job site.
    - Demonstrate how quality and quantity of work increases when using the correct tools and tools in good condition as compared to using the wrong tool and tools in poor condition.
    - Explain your policy for repair and replacement of broken and damaged tools.
  3. Use Information Sheet, Sections III, IV and V, to discuss tools used in HVAC.
    - Display examples of tools and equipment listed in this section of the information sheet.
    - Allow students to handle the tools so they may become familiar with how each of them operates.
    - Discuss and demonstrate proper use of each hand tool, including the tools used in Assignment Sheets #1 through #3.





## SUGGESTED ACTIVITIES

- Have students demonstrate proper use of each tool; correct them when they are not using tools properly, and show them the proper way to use tools.
- H. Review information sheet.
  - I. Give test.
  - J. Critique test and discuss in class.
  - K. Reteach and retest as necessary.
  - L. Complete appropriate section of competency profiles.
- III. Unit references.
- A. Wantiez, Gary W. *Air Conditioning and Refrigeration Fundamentals*. Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, Inc., 1984.
  - B. Zinngarbe, Claude J. *Sheet Metal Blueprint Reading for the Building Trades*. Albany, New York: Delmar Publishers, a division of Litton Educational Publishing, Inc., 1984.

## HVAC TOOLS UNIT II

### INFORMATION SHEET

- I. Terms and definitions associated with HVAC tools
  - A. **Safety** — Freedom from danger, risk, or injury
  - B. **Accessory** — Object or device not essential in itself but adding to the beauty, convenience, or effectiveness of something else
  - C. **Swage** — Enlarging of one end of a tube so that the end of another tube of the same size will fit into it
  - D. **Flare** — Enlarging the end of a piece of tubing to a 45-degree angle to allow a flared fitting to seal tight against it
  - E. **Circumference rule** — 3- and 4-foot rules used to find the circumference of a circle; cannot be used to measure directly
  - F. **Pipe die** — Device used to cut threads on the outside of pipe
  - G. **Pipe reamer** — Tool used to smooth the inside edges at the end of a piece of pipe by removing burrs and other rough places

- II. Guidelines for care and safe use of HVAC tools
  - A. Use the correct tool for the job being done
  - B. Keep tools clean, sharp, and in good condition
  - C. Inspect tools and accessories regularly
  - D. Repair broken or damaged tools promptly
  - E. Dispose of broken or damaged tools that cannot be repaired
  - F. Store tools properly

EXAMPLES: Do not carry tools in your pockets; do not place tools where they can roll off; protect cutting edges; lightly oil tools before storing; store tools in dry place.

- G. Stay alert when using tools
- H. Wear eye protection when necessary
- I. Wear appropriate clothing for job being performed
- J. Do not attempt to operate any power tool before getting instructor's approval on that particular tool



## INFORMATION SHEET

- K. Do not leave power tools running unattended
- L. Assume a safe and comfortable position before using a power tool
- M. Be sure power tools are properly grounded before using
- N. Do not use power tools without guards or safety devices
- O. Keep a firm grip on the power tool while it is in use
- P. Protect all testing equipment and instruments from shock and vibration
- Q. Report any condition that may lead to an accident
- R. Report any unusual noises, sounds, or vibrations to the instructor or supervisor
- S. Be sure that power tools are disconnected before performing maintenance or changing accessories
- T. Follow manufacturer's maintenance procedures

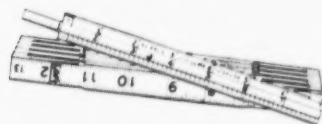
## III. Common hand tools

## A. Measuring devices

## 1. Rules

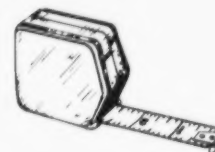
## a. Folding rule

FIGURE 1



## b. Steel tape

FIGURE 2



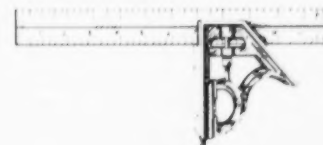
## c. 100-foot tape

FIGURE 3



## d. Combination square

FIGURE 4

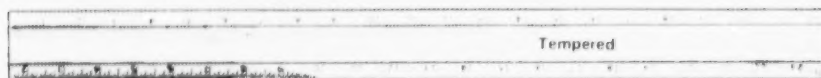


Figures 1-4 used with permission of Mid-America Vocational Curriculum Consortium, Inc., Stillwater, OK.

## INFORMATION SHEET

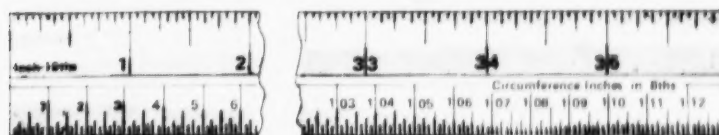
## e. Steel rule (bench rule)

FIGURE 5



## f. Circumference rule

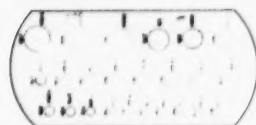
FIGURE 6



## 2. Gauges

## a. Drill

FIGURE 7



## b. Wire

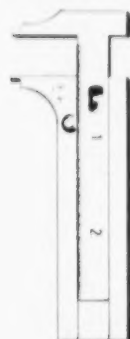
FIGURE 8



## 3. Calipers

## a. Slide

FIGURE 9



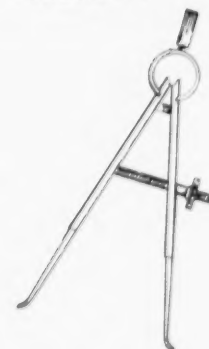
## b. Outside

FIGURE 10



## c. Inside

FIGURE 11



Figures 5-11 used with permission of Mid-America Vocational Curriculum Consortium, Inc., Stillwater, OK.



## INFORMATION SHEET

## 4. Micrometers

## a. Outside

FIGURE 12



## b. Inside

FIGURE 13



## B. Screwdrivers

## 1. Standard (flat blade)

FIGURE 14



## 2. Phillips head

FIGURE 15



## 3. Clutch head

FIGURE 16



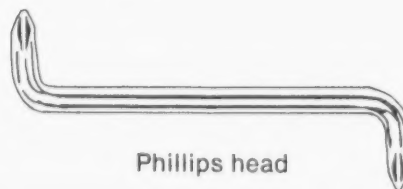
## 4. Offset

FIGURE 17



Flat blade

FIGURE 18



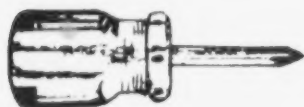
Phillips head

Figures 12-13 used with permission of Mid-America Vocational Curriculum Consortium, Inc., Stillwater, OK.

## INFORMATION SHEET

## 5. Stubby

FIGURE 19



## C. Pliers

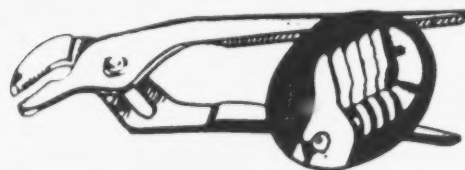
## 1. Combination slip joint

FIGURE 20



## 3. Channel-lock (slip joint)

FIGURE 22



## 5. Vise grip

FIGURE 24



## D. Wrenches

## 1. Open end

FIGURE 26



## 2. Long nose

FIGURE 21



## 4. Diagonal

FIGURE 23



## 6. Pinch-off

FIGURE 25



## 2. Box end

FIGURE 27



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## INFORMATION SHEET

## 3. Combination

FIGURE 28



## 4. Flare nut

FIGURE 29



## 5. Crescent (adjustable)

FIGURE 30



## 6. Pipe

FIGURE 31



## 7. Nut driver

FIGURE 32



## 8. Allen (hex key)

FIGURE 33



## E. Hammers

## 1. Soft face

FIGURE 34



## 2. Riveting

FIGURE 35



## F. Files

## 1. Flat

FIGURE 36



## 2. Triangular (three square)

FIGURE 37



Figures 28-35 used with permission of Mid-America Vocational Curriculum Consortium, Inc., Stillwater, OK.

## INFORMATION SHEET

## 3. Round

FIGURE 38



## 4. Slitting

FIGURE 39



## G. Punches, chisels, and bars

## 1. Pin punch

FIGURE 40



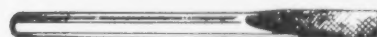
## 2. Center punch

FIGURE 41



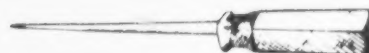
## 3. Cold chisel

FIGURE 42



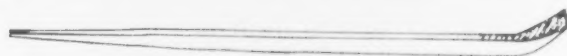
## 4. Scratch awl

FIGURE 43



## 5. Pry bar

FIGURE 44



## H. Threading tools

## 1. Tap

FIGURE 45



## 2. Die

FIGURE 46



Figures 38-46 used with permission of Mid-America Vocational Curriculum Consortium, Inc., Stillwater, OK.



## INFORMATION SHEET

## 3. Hand tap wrench

FIGURE 47

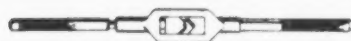
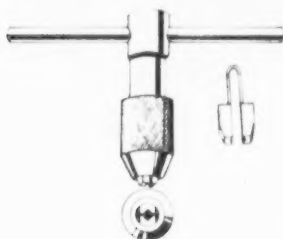
4. Hand die wrench  
(die stock)

FIGURE 48



## 5. T-handle tap wrench

FIGURE 49

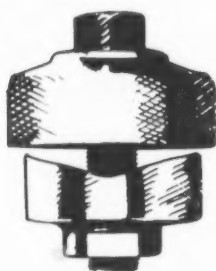


## IV. Accessory tools used in HVAC

## A. Tools used to make holes

## 1. Knock-out cutter

FIGURE 50



## 2. Hole saw

FIGURE 51



## 3. Twist drill

FIGURE 52



## 4. Speed bit

FIGURE 53



Figures 47, 48, 49, 50, 52, and 53 used with permission of Mid-America Vocational Curriculum Consortium, Inc., Stillwater, OK.

# INFORMATION SHEET

## 5. Masonry bit

FIGURE 54



## 6. Auger bit

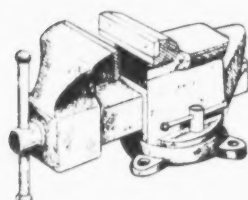
FIGURE 55



## B. Vises

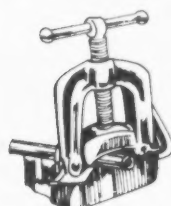
### 1. Bench

FIGURE 56



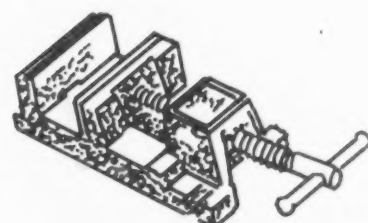
### 2. Pipe

FIGURE 57



### 3. Drill press

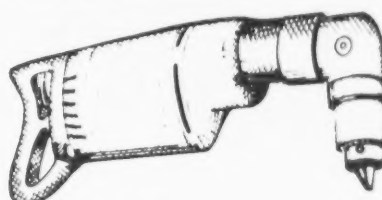
FIGURE 58



## C. Power tools

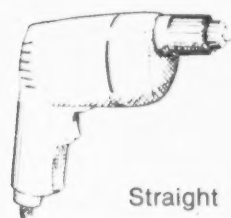
### 1. Drill motors

FIGURE 59



Angle

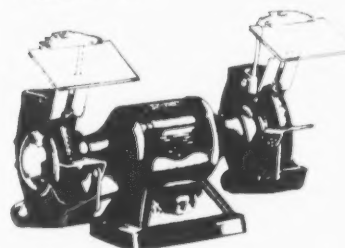
FIGURE 60



Straight

### 2. Bench grinder

FIGURE 61



Figures 54, and 56-61 used with permission of Mid-America Vocational Curriculum Consortium, Inc., Stillwater, OK.

## INFORMATION SHEET

## V. Specialty tools used in HVAC

## A. Tubing tools

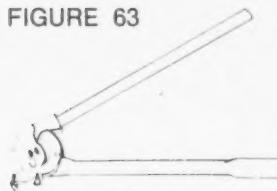
## 1. Tubing cutter with reamer

FIGURE 62



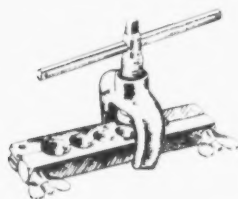
## 2. Lever-type bender

FIGURE 63



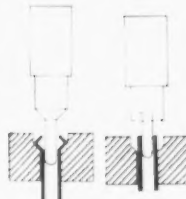
## 3. Flaring tools and block

FIGURE 64



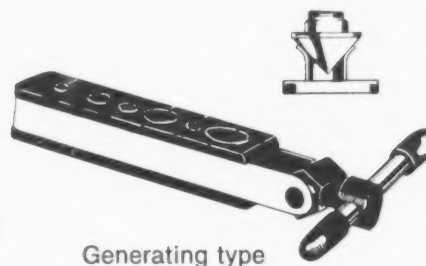
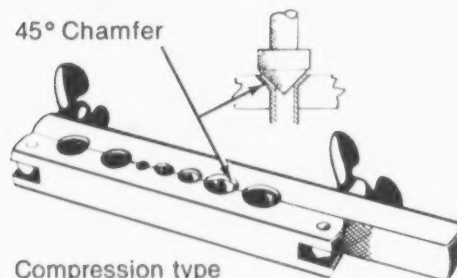
## 4. Double-flare punches

FIGURE 65



## 5. Flaring blocks

FIGURE 66



## 6. Bending spring

FIGURE 67



## 7. Swage punch

FIGURE 68



Figures 62-68 used with permission of Mid-America Vocational Curriculum Consortium, Inc., Stillwater, OK.

## INFORMATION SHEET

## B. Pipe cutting and threading tools

1. Pipe cutter

FIGURE 69



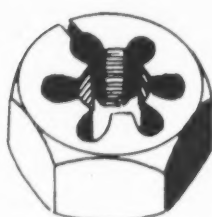
2. Die stock

FIGURE 70



3. Pipe die

FIGURE 71



4. Pipe reamer

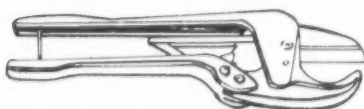
FIGURE 72



## C. PVC Tools

1. PVC cutter

FIGURE 73



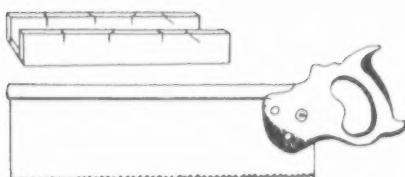
2. PVC knife

FIGURE 74



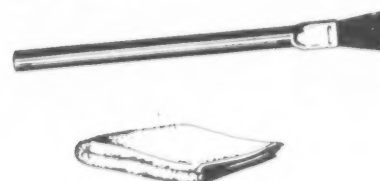
3. Miter saw and miter box

FIGURE 75



4. PVC cement brush and cleaning cloth

FIGURE 76



Figures 69-76 used with permission of Mid-America Vocational Curriculum Consortium, Inc., Stillwater, OK.

## INFORMATION SHEET

## 5. PVC cleaner

FIGURE 77



## PVC cement

FIGURE 78

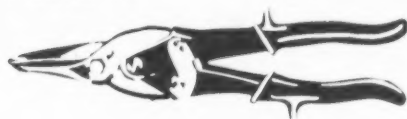


## D. Sheet metal tools

## 1. Aviation snips

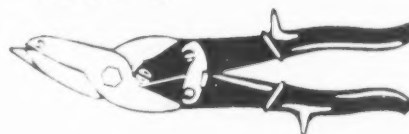
(NOTE: These are also available in left and right hand cut.)

FIGURE 79



## 2. Double cutting snips

FIGURE 80



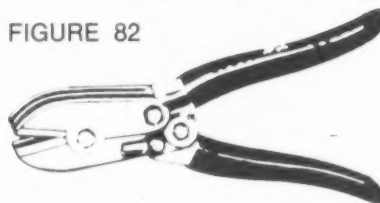
## 3. Combination pattern snips

FIGURE 81



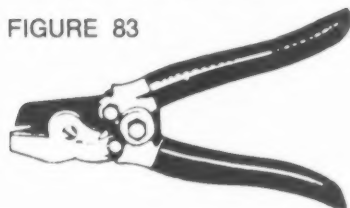
## 4. Hand crimper

FIGURE 82



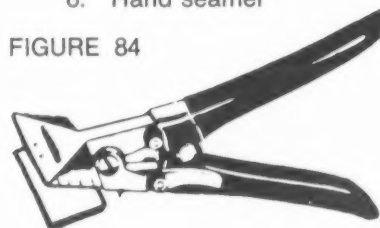
## 5. Hand notcher

FIGURE 83



## 6. Hand seamer

FIGURE 84



Figures 77-84 used with permission of Mid-America Vocational Curriculum Consortium, Inc., Stillwater, OK.

## INFORMATION SHEET

7. Riveter

FIGURE 85



8. Refrigeration ratchet wrench

FIGURE 86



9. Brass tubing brush

FIGURE 87

10. Emery cloth  
(sand cloth)

FIGURE 88



11. Safety goggles

FIGURE 89

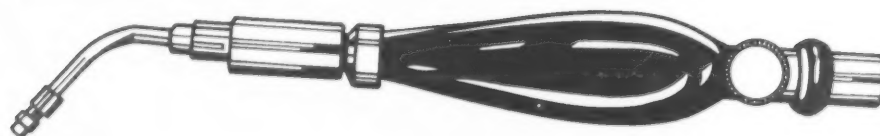
12. Colored safety  
(flash) glasses

FIGURE 90



13. Soldering torch

FIGURE 91



Figures 85 and 86 used with permission of Mid-America Vocational Curriculum Consortium, Inc., Stillwater, OK.

# HVAC TOOLS UNIT II

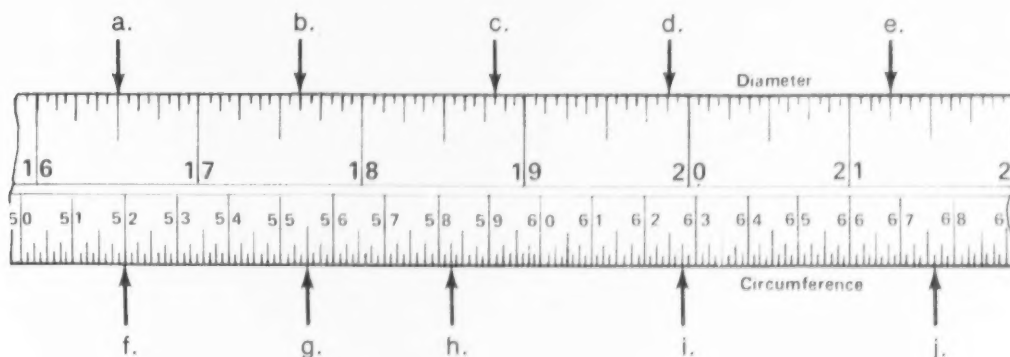
## ASSIGNMENT SHEET #1 — READ THE CIRCUMFERENCE RULE

NAME \_\_\_\_\_

SCORE \_\_\_\_\_

1. Using the circumference rule shown, determine the circumference for the diameters a to e, and the corresponding diameters for the indicated circumferences f to j. Place answers in the columns below.

(NOTE: Read diameters to closest  $\frac{1}{16}$ " and circumferences to closest  $\frac{1}{8}$ ".)



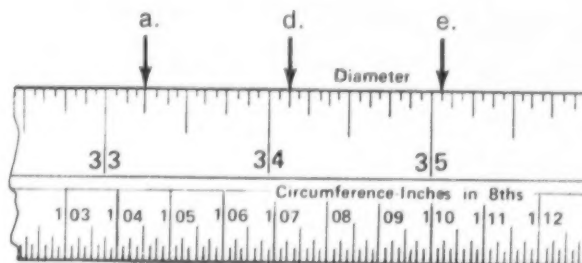
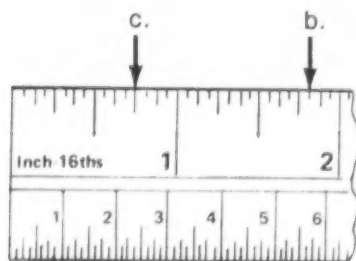
|    |       |    |       |
|----|-------|----|-------|
| a. | _____ | f. | _____ |
| b. | _____ | g. | _____ |
| c. | _____ | h. | _____ |
| d. | _____ | i. | _____ |
| e. | _____ | j. | _____ |

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## ASSIGNMENT SHEET #1

2. The diameters below are noted on the circumference rule. Find the corresponding circumferences for each diameter and place answers in the column area.

a.  $33 \frac{1}{4}$ " dia.c.  $34 \frac{3}{4}$ " dia.e.  $35 \frac{1}{16}$ " dia.b.  $1 \frac{13}{16}$ " dia.d.  $34 \frac{1}{8}$ " dia.

a. \_\_\_\_\_

b. \_\_\_\_\_

c. \_\_\_\_\_

d. \_\_\_\_\_

e. \_\_\_\_\_

Adapted with permission of Mid-America Vocational Curriculum Consortium, Inc., Stillwater, OK.



HVAC TOOLS  
UNIT II

## ASSIGNMENT SHEET #2 — USE THE INSIDE AND OUTSIDE CALIPERS

NAME \_\_\_\_\_ SCORE \_\_\_\_\_

1. Measure the i.d. (inside diameter) of three pieces of tubing with a pair of calipers and transfer the measurement to a rule.
2. Measure the o.d. (outside diameter) of three pieces of tubing with a pair of calipers and transfer the measurement to a rule.
3. Record measurements.

(NOTE: Mark tubing for reference.)

## 4. I.D.

a. \_\_\_\_\_

b. \_\_\_\_\_

c. \_\_\_\_\_

## 5. O.D.

a. \_\_\_\_\_

b. \_\_\_\_\_

c. \_\_\_\_\_

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# HVAC TOOLS UNIT II

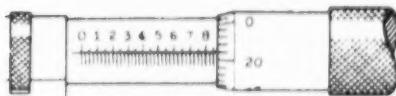
## ASSIGNMENT SHEET #3 — READ THE MICROMETER SETTINGS

NAME \_\_\_\_\_

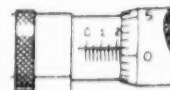
SCORE \_\_\_\_\_

Using the procedure given below, read the micrometer settings and write your answers in the blanks provided.

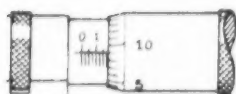
- A. Each numbered graduation on the sleeve represents 0.100" (one-hundred thousandths of an inch).
- B. Each small graduation on the sleeve between the numbered graduations represents 0.025" (twenty-five thousandths of an inch).
- C. Each graduation found on the thimble represents 0.001" (one thousandth of an inch).
- D. Total the reading by adding the three values.



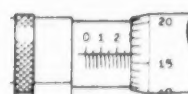
1. \_\_\_\_\_



2. \_\_\_\_\_



3. \_\_\_\_\_

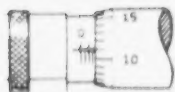


4. \_\_\_\_\_

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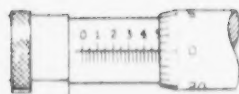
## ASSIGNMENT SHEET #3



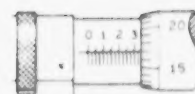
5. \_\_\_\_\_



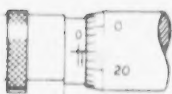
6. \_\_\_\_\_



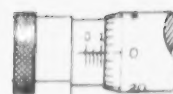
7. \_\_\_\_\_



8. \_\_\_\_\_



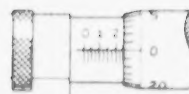
9. \_\_\_\_\_



10. \_\_\_\_\_



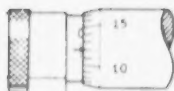
11. \_\_\_\_\_



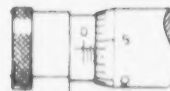
12. \_\_\_\_\_

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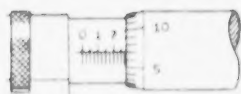
## ASSIGNMENT SHEET #3



13. \_\_\_\_\_



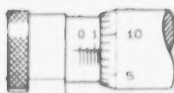
14. \_\_\_\_\_



15. \_\_\_\_\_



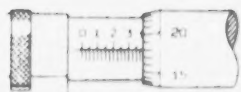
16. \_\_\_\_\_



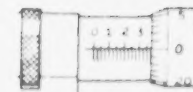
17. \_\_\_\_\_



18. \_\_\_\_\_



19. \_\_\_\_\_



20. \_\_\_\_\_

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HVAC TOOLS  
UNIT II

## ANSWERS TO ASSIGNMENT SHEETS

## Assignment Sheet #1

- |    |                       |                        |
|----|-----------------------|------------------------|
| 1. | a. $51 \frac{7}{8}"$  | f. $16 \frac{9}{16}"$  |
|    | b. $55 \frac{3}{8}"$  | g. $17 \frac{11}{16}"$ |
|    | c. $59 \frac{1}{8}"$  | h. $18 \frac{9}{16}"$  |
|    | d. $62 \frac{1}{2}"$  | i. $19 \frac{15}{16}"$ |
|    | e. $66 \frac{3}{4}"$  | j. $21 \frac{1}{2}"$   |
| 2. | a. $104 \frac{1}{2}"$ | d. $107 \frac{1}{4}"$  |
|    | b. $5 \frac{5}{8}"$   | e. $110 \frac{1}{8}"$  |
|    | c. $2 \frac{3}{8}"$   |                        |

Assignment Sheet #2 — Evaluated to the satisfaction of the instructor.

## Assignment Sheet #3

- |          |           |           |           |
|----------|-----------|-----------|-----------|
| 1. 0.871 | 6. 0.023  | 11. 0.613 | 16. 0.100 |
| 2. 0.226 | 7. 0.500  | 12. 0.250 | 17. 0.133 |
| 3. 0.184 | 8. 0.342  | 13. 0.012 | 18. 0.053 |
| 4. 0.291 | 9. 0.047  | 14. 0.079 | 19. 0.393 |
| 5. 0.086 | 10. 0.125 | 15. 0.282 | 20. 0.375 |



# HVAC TOOLS UNIT II

## TEST

NAME \_\_\_\_\_

SCORE \_\_\_\_\_

1. Match terms associated with HVAC to their correct definitions. Write the correct numbers in the blanks.

- |                                                                                                                             |                       |
|-----------------------------------------------------------------------------------------------------------------------------|-----------------------|
| _____ a. Freedom from danger, risk, or injury                                                                               | 1. Swage              |
| _____ b. Object or device not essential in itself but adding to the beauty, convenience, or effectiveness of something else | 2. Circumference rule |
| _____ c. Enlarging of one end of a tube so that the end of another tube of the same size will fit into it                   | 3. Pipe reamer        |
| _____ d. Enlarging the end of a piece of tubing to a 45 degree angle to allow a flared fitting to seal tight against it     | 4. Accessory          |
| _____ e. 3- and 4-foot rules used to find the circumference of a circle; cannot be used to measure directly                 | 5. Pipe die           |
| _____ f. Device used to cut threads on the outside of pipe                                                                  | 6. Safety             |
| _____ g. Tool used to smooth the inside edges at the end of a piece of pipe by removing burrs and other rough places        | 7. Flare              |

2. State ten guidelines for care and safe use of HVAC tools.

- a. \_\_\_\_\_  
\_\_\_\_\_
- b. \_\_\_\_\_  
\_\_\_\_\_
- c. \_\_\_\_\_  
\_\_\_\_\_
- d. \_\_\_\_\_  
\_\_\_\_\_



## TEST

- e. \_\_\_\_\_  
 \_\_\_\_\_
- f. \_\_\_\_\_  
 \_\_\_\_\_
- g. \_\_\_\_\_  
 \_\_\_\_\_
- h. \_\_\_\_\_  
 \_\_\_\_\_
- i. \_\_\_\_\_  
 \_\_\_\_\_
- j. \_\_\_\_\_  
 \_\_\_\_\_

3. Identify common hand tools used in HVAC illustrated below. Write their correct names in the blanks.

**Steel tape**  
**Folding rule**  
**Inside calipers**  
**100-foot tape**  
**Outside calipers**

**Combination square**  
**Steel rule (bench rule)**  
**Inside micrometers**  
**Slide calipers**

**Circumference rule**  
**Outside micrometers**  
**Drill gauge**  
**Wire gauge**

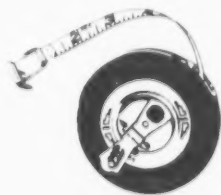
a. Measuring devices



1. \_\_\_\_\_



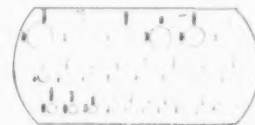
2. \_\_\_\_\_



3. \_\_\_\_\_



4. \_\_\_\_\_

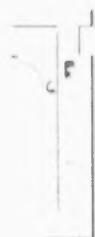


5. \_\_\_\_\_

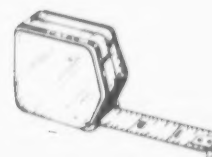
# TEST



6. \_\_\_\_\_



7. \_\_\_\_\_



8. \_\_\_\_\_



9. \_\_\_\_\_



10. \_\_\_\_\_



11. \_\_\_\_\_



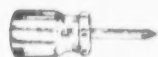
12. \_\_\_\_\_



13. \_\_\_\_\_

## b. Screwdrivers

Standard (flat blade)  
Stubby



1. \_\_\_\_\_

Phillips head  
Offset flat blade

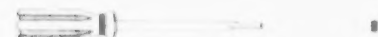


2. \_\_\_\_\_

Clutch head  
Offset Phillips head



3. \_\_\_\_\_



4. \_\_\_\_\_



5. \_\_\_\_\_



6. \_\_\_\_\_





## TEST

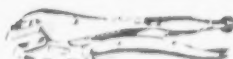
## c. Pliers

Long nose  
Combination slip joint



1. \_\_\_\_\_

Diagonal  
Pinch-off



2. \_\_\_\_\_

Vise grip  
Channel lock (slip joint)



3. \_\_\_\_\_



4. \_\_\_\_\_



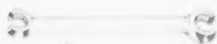
5. \_\_\_\_\_



6. \_\_\_\_\_

## d. Wrenches

Box end  
Crescent (adjustable)  
Nut driver



1. \_\_\_\_\_

Allen (hex key)  
Open end  
Pipe

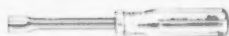


2. \_\_\_\_\_

Flare nut  
Combination



3. \_\_\_\_\_



4. \_\_\_\_\_



5. \_\_\_\_\_



6. \_\_\_\_\_



7. \_\_\_\_\_



8. \_\_\_\_\_

## TEST

## e. Hammers

Soft face

Riveting



1. \_\_\_\_\_ 2. \_\_\_\_\_

## f. Files

Flat

Triangular (three square)

Round

Slitting



1. \_\_\_\_\_ 2. \_\_\_\_\_



3. \_\_\_\_\_ 4. \_\_\_\_\_

## g. Punches, chisels and bars

Scratch awl  
Center punchCold chisel  
Pin punch

Pry bar



1. \_\_\_\_\_ 2. \_\_\_\_\_



3. \_\_\_\_\_ 4. \_\_\_\_\_ 5. \_\_\_\_\_



## TEST

## h. Threading tools

Hand die wrench (die stock)  
Hand tap wrench



Die  
Tap



T-handle tap wrench



1. \_\_\_\_\_ 2. \_\_\_\_\_ 3. \_\_\_\_\_



4. \_\_\_\_\_ 5. \_\_\_\_\_

4. Identify accessory tools used in HVAC illustrated below. Write the correct names in the blanks.

## a. Tools used to cut holes

Knock-out cutter  
Hole saw



Auger bit  
Twist drill



Masonry bit  
Speed bit



1. \_\_\_\_\_ 2. \_\_\_\_\_ 3. \_\_\_\_\_



4. \_\_\_\_\_ 5. \_\_\_\_\_ 6. \_\_\_\_\_

## TEST

## b. Vises

Drill press



1. \_\_\_\_\_

Bench



2. \_\_\_\_\_

Pipe



3. \_\_\_\_\_

## c. Power tools

Bench grinder



1. \_\_\_\_\_

Straight drill motor



2. \_\_\_\_\_

Angle drill motor

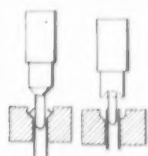


3. \_\_\_\_\_

5. Identify specialty tools used in HVAC illustrated below. Write the correct names in the blanks.

## a. Tubing tools

Lever-type bender  
Compression-type flaring  
block



1. \_\_\_\_\_

Double-flare punches  
Tubing cutter with reamer  
Flaring tool and block



2. \_\_\_\_\_

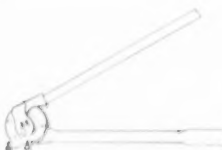
Swage punch  
Bending spring  
Generating-type flaring  
block



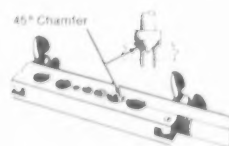
3. \_\_\_\_\_



4. \_\_\_\_\_



5. \_\_\_\_\_



6. \_\_\_\_\_



## TEST



7. \_\_\_\_\_ 8. \_\_\_\_\_

## b. Pipe cutting and threading tools

Die stock

Pipe reamer

Pipe cutter

Pipe die



1. \_\_\_\_\_ 2. \_\_\_\_\_ 3. \_\_\_\_\_



4. \_\_\_\_\_

## c. PVC tools

PVC knife  
PVC cleaner  
PVC cutter

PVC cement brush and  
cleaning cloth

Miter saw and miter box  
PVC cement



1. \_\_\_\_\_ 2. \_\_\_\_\_ 3. \_\_\_\_\_



4. \_\_\_\_\_ 5. \_\_\_\_\_ 6. \_\_\_\_\_

## TEST

## d. Sheet metal tools

Double cutting snips

Riveter

Combination pattern snips

Brass tubing brush

Colored safety  
(flash) glasses

Hand crimper

Hand seamer

Hand notcher

Emergency cloth  
(sand cloth)

Refrigeration ratchet wrench

Aviation snips

Soldering torch

Safety goggles



1. \_\_\_\_\_



2. \_\_\_\_\_



3. \_\_\_\_\_



4. \_\_\_\_\_



5. \_\_\_\_\_



6. \_\_\_\_\_



7. \_\_\_\_\_



8. \_\_\_\_\_



9. \_\_\_\_\_



10. \_\_\_\_\_



11. \_\_\_\_\_



12. \_\_\_\_\_



13. \_\_\_\_\_

## TEST

(NOTE: Test items 6 through 8 list the assignment sheets. They are an important part of this test. If they have not been completed, check with your instructor.)

6. Read a circumference rule.
7. Use inside and outside calipers.
8. Read micrometer settings.

# HVAC TOOLS UNIT II

## ANSWERS TO TEST

1.   a. 6                      c. 1                      e. 2                      g. 3  
      b. 4                      d. 7                      f. 5
  
2. Answer should include any ten of the following.
  - a. Use the correct tool for the job being done
  - b. Keep tools clean, sharp, and in good condition
  - c. Inspect tools and accessories regularly
  - d. Repair broken or damaged tools promptly
  - e. Dispose of broken or damaged tools that cannot be repaired
  - f. Store tools properly
  - g. Stay alert when using tools
  - h. Wear eye protection when necessary
  - i. Wear appropriate clothing for job being performed
  - j. Do not attempt to operate any power tool before getting instructor's approval on that particular tool
  - k. Do not leave power tools running unattended
  - l. Assume a safe and comfortable position before using a power tool
  - m. Be sure power tools are properly grounded before using
  - n. Do not use power tools without guards or safety devices
  - o. Keep a firm grip on the power tool while it is in use
  - p. Protect all testing equipment and instruments from shock and vibration
  - q. Report any condition that may lead to an accident
  - r. Report any unusual noises, sounds, or vibrations to the instructor or supervisor
  - s. Be sure that power tools are disconnected before performing maintenance or changing accessories
  - t. Follow manufacturer's maintenance procedures
  
3. a. Measuring devices
 

|                            |                       |                         |
|----------------------------|-----------------------|-------------------------|
| 1. Inside micrometers      | 6. Combination square | 11. Outside micrometers |
| 2. Steel rule (bench rule) | 7. Slide calipers     | 12. Circumference rule  |
| 3. 100-foot rule           | 8. Steel tape         | 13. Outside calipers    |
| 4. Inside calipers         | 9. Folding rule       |                         |
| 5. Drill gauge             | 10. Wire gauge        |                         |
  
- b. Screwdrivers
 

|                          |                      |                         |
|--------------------------|----------------------|-------------------------|
| 1. Stubby                | 3. Offset flat blade | 5. Phillips head        |
| 2. Standard (flat blade) | 4. Clutch head       | 6. Offset Phillips head |

90





## ANSWERS TO TEST

## c. Pliers

- |              |                           |                                 |
|--------------|---------------------------|---------------------------------|
| 1. Pinch-off | 3. Diagonal               | 5. Channel-lock<br>(slip joint) |
| 2. Vise grip | 4. Combination slip joint | 6. Long nose                    |

## d. Wrenches

- |                          |                |                    |
|--------------------------|----------------|--------------------|
| 1. Flare nut             | 4. Nut driver  | 7. Allen (hex key) |
| 2. Crescent (adjustable) | 5. Pipe        | 8. Box end         |
| 3. Open end              | 6. Combination |                    |

## e. Hammers

- |             |              |
|-------------|--------------|
| 1. Riveting | 2. Soft face |
|-------------|--------------|

## f. Files

- |                              |             |
|------------------------------|-------------|
| 1. Triangular (three square) | 3. Slitting |
| 2. Round                     | 4. Flat     |

## g. Punches, chisels and bars

- |                |                |                 |
|----------------|----------------|-----------------|
| 1. Scratch awl | 3. Pin punch   | 5. Center punch |
| 2. Pry bar     | 4. Cold chisel |                 |

## h. Threading tools

- |                        |                                   |                    |
|------------------------|-----------------------------------|--------------------|
| 1. T-handle tap wrench | 3. Die                            | 5. Hand tap wrench |
| 2. Tap                 | 4. Hand die wrench<br>(die stock) |                    |

## 4. a. Tools used to cut holes

- |                |                |                     |
|----------------|----------------|---------------------|
| 1. Masonry bit | 3. Twist drill | 5. Auger bit        |
| 2. Speed bit   | 4. Hole saw    | 6. Knock-out cutter |

## b. Vises

- |                |          |         |
|----------------|----------|---------|
| 1. Drill press | 2. Bench | 3. Pipe |
|----------------|----------|---------|

## ANSWERS TO TEST

## c. Power tools

1. Straight drill motor
2. Bench grinder
3. Angle drill motor

## 5. a. Tubing tools

1. Double-flare punches
2. Generating-type flaring block
3. Tubing cutter with reamer
4. Flaring tool and block
5. Lever-type bender
6. Compression-type flaring block
7. Swage punch
8. Bending spring

## b. Pipe cutting and threading tools

1. Pipe die
2. Pipe reamer
3. Pipe cutter
4. Die stock

## c. PVC tools

1. PVC cement
2. Miter saw and box
3. PVC cleaner
4. PVC cutter
5. PVC cement brush and cleaning cloth
6. PVC knife

## d. Sheet metal tools

1. Hand crimper
2. Hand seamer
3. Riveter
4. Combination pattern snips
5. Hand notcher
6. Aviation snips
7. Refrigeration ratchet wrench
8. Double cutting snips
9. Colored safety (flash) glasses
10. Soldering torch
11. Brass tubing brush
12. Safety goggles
13. Emery cloth (sand cloth)

6. Evaluated to the satisfaction of the instructor.

7. Evaluated to the satisfaction of the instructor.

8. Evaluated to the satisfaction of the instructor.



HVAC LAYOUT  
UNIT III

## UNIT OBJECTIVE

After completing this unit, the student should be able to identify types of warm-air heating systems, hydronic system designs, and types of supply duct systems. The student should also be able to list advantages of forced-air systems, factors affecting return-air duct design, and factors to consider in the distribution of conditioned air. In addition, the student should be able to use the friction charts. The student will show this ability by completing the assignment sheets and the unit test with a minimum score of 80 percent.

## SPECIFIC OBJECTIVES

After completing this unit, the student should be able to

1. Match terms associated with HVAC layout to their correct definitions.
2. Label illustrations of various types of warm-air heating systems.
3. Name types of fuels used as the principal means of domestic heat.
4. Name methods of delivery for warm-air heating systems.
5. Select advantages of the forced-air systems.
6. Identify common hydronic system designs.
7. Distinguish between the two basic types of hydronic systems.
8. Identify types of supply duct systems.
9. Match factors affecting system design with the effects they have on the system.
10. Match major steps of air system design with the correct procedures for completing each step.
11. Select factors affecting return-air duct design.
12. List locations of registers and grilles.
13. Describe climatic zone conditions.
14. Name factors to consider in the distribution of conditioned air.
15. Match significant room-air patterns as determined by outlet placement with their recommended velocities.



## OBJECTIVE SHEET

16. Solve problems using the friction loss per 100 feet chart.
17. Solve problems using the friction chart.
18. Design air distribution system from a drawing.

HVAC LAYOUT  
UNIT III

## SUGGESTED ACTIVITIES

- I. Unit contents
  - A. Objective sheet
  - B. Suggested activities
  - C. Transparency masters
    - 1. TM #1 — Duct Fittings and Equivalent Lengths (Group 1)
    - 2. TM #2 — Duct Fittings and Equivalent Lengths (Group 3)
    - 3. TM #3 — Duct Fittings and Equivalent Lengths (Group 4)
    - 4. TM #4 — Duct Fittings and Equivalent Lengths (Group 5)
    - 5. TM #5 — Duct Fittings and Equivalent Lengths (Group 6)
    - 6. TM #6 — Duct Fittings and Equivalent Lengths (Group 7)
    - 7. TM #7 — Rectangular Duct Equivalents
    - 8. TM #8 — Climate Zone Map for System Selection
    - 9. TM #9 — Friction Loss Per 100 Feet Chart
    - 10. TM #10 — Suggested Static Pressures for Duct Design
    - 11. TM #11 — Friction Chart
  - D. Information sheet
  - E. Assignment sheets
    - 1. Assignment Sheet #1 — Solve Problems Using the Friction Loss Per 100 Feet Chart
    - 2. Assignment Sheet #2 — Solve Problems Using the Friction Chart
    - 3. Assignment Sheet #3 — Design an Air Distribution System from a Drawing
  - F. Answers to assignment sheets
  - G. Test
  - H. Answers to test



## SUGGESTED ACTIVITIES

## II. Instructor's guide

- A. Review unit and plan presentation.
- B. Obtain materials to supplement unit.

## 1. Books and publications

(NOTE: When ordering books, catalogs, publications, etc., always request the newest editions.)

- a. *Refrigeration and Air Conditioning* by Lee Miles

(NOTE: Order from Prentice-Hall, Inc., Englewood Cliffs, New Jersey 07632.)

- b. *Refrigeration and Air Conditioning Technology* by William G. Whitman and William M. Johnson.

(NOTE: Order from Delmar Publishers, Inc., 2 Computer Drive West, Box 15-015, Albany, New York 12212.)

- c. *Sheet Metal Blueprint Reading for the Building Trades* by Claude J. Zinngrabe.

(NOTE: Order from Delmar Publishers, Inc., 2 Computer Drive West, Box 15-015, Albany, New York 12212.)

- d. *Air Conditioning and Refrigeration Fundamentals* by Gary W. Wantiez.

- e. *Air Conditioning and Refrigeration* Book III and Book IV by William Eckes and Dan Fulkerson.

(NOTE: Order the latter two books from Mid-America Vocational Curriculum Consortium, Inc., Oklahoma State Department of Vocational and Technical Education, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074-4364.)

## 2. Film

*Heating and Cooling Specialist*, 16mm, color, 10 min., 1975 Core

(NOTE: This film discusses the training needed to become a heating and cooling specialist. Promotional film for Lennox Industries.)

This film is available on loan to Oklahoma instructors from the Oklahoma State Department of Vocational and Technical Education/Curriculum and Instructional Materials Center, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074-4364.

## 3. Competency profiles

(NOTE: A master of the competency profile for this book is provided at the front of the instructor edition. You may duplicate the profile and distribute it to students as needed.)

## SUGGESTED ACTIVITIES

- C. Make copies of transparencies.
- D. Introduce unit to students.
  - Invite an HVAC specialist to discuss HVAC layout with the class.
  - Discuss layout of warm-air systems, hydronic system designs, supply duct systems and return-air duct designs.
- E. Provide students with objective sheet.
- F. Discuss unit and specific objectives.
- G. Provide students with information and assignment sheets.
- H. Discuss information and assignment sheets.
  - 1. Use Information Sheet, Section I, to discuss terms and definitions associated with HVAC layout.
    - Point out the importance of defining terms for common understanding, and for better understanding of this unit.
  - 2. Use Information Sheet, Section II, to discuss types of warm-air heating systems.
    - Discuss the various types of heating systems and the types of structures in which they are installed.
    - Have students check the systems in their homes, and then discuss all the systems and any variations they may have noticed.
    - Discuss which system is the most popular in your particular location and why.
  - 3. Use Information Sheet, Section III, to discuss types of fuels used in domestic heating.
    - Discuss with the students which type of fuel is used in their homes; have them give reasons why they think this particular type of fuel was used. Which is the most popular in your location?
    - Discuss which is the most economical type of fuel, which seems to do the best job, and which is the cleanest.
  - 4. Use Information Sheet, Sections IV and V, to discuss the methods of delivery for warm-air heating systems.
    - Discuss the gravity and forced delivery methods; compare one with the other, and discuss which is used more often.
    - Discuss the advantages of the forced-air system as compared to the gravity flow system.



## SUGGESTED ACTIVITIES

5. Use Information Sheet, Sections VI and VII, to discuss hydronic system designs and basic types of hydronic systems.
  - Discuss how the hydronic system works and how steam and hot water are used to convey heat energy.
  - Discuss how the piping system takes up less space and is much cleaner than the duct system.
  - Compare hydronic systems to warm-air heating systems.
6. Use Information Sheet, Sections VIII and IX, to discuss types of supply duct systems, factors that affect the system design, and what these effects are.
  - Discuss the various types of duct systems, why one system is used instead of another, and advantages and disadvantages of each system.
  - Discuss the factors that affect the system design and what effect they have on the system.
  - Discuss how heat is lost when extra long ducts are used, and how heat loss occurs when a lot of offset fittings are used.
  - Discuss heat loss in uninsulated ducts as compared to properly insulated ducts.
7. Use Information Sheet, Sections X through XV, to discuss the procedures used to design the proper air system, factors affecting return-air duct design, register and grille locations, climate zone conditions, and room-air patterns.
  - Discuss procedures that will help to determine the proper air distribution system.
  - Discuss procedures that will help you select the proper equipment.
  - Discuss information and procedures needed to lay out and size ductwork.
  - Discuss what information is needed to select the proper registers and grilles for the supply and return air.
  - Use Transparencies #1 through #8 to help reinforce your discussions.
8. Use Information Sheet, Sections XVI and XVII, to learn how to use the friction loss per 100 feet chart and the friction chart.
  - Discuss friction and how it affects the air distribution system and the duct design.
  - Discuss the instructions for using the friction loss per 100 feet chart and the friction chart.



## SUGGESTED ACTIVITIES

- Use Transparencies #1 through #11 to reinforce your discussion and to help complete the assignment sheets.
- Have students complete Assignment Sheets #1, #2, and #3.

I. Review unit.

J. Give test.

K. Reteach and retest as necessary.

L. Complete appropriate sections of competency profiles.

III. Unit references

- A. Eckes, William and Dan Fulkerson. *Air Conditioning and Refrigeration Book III*. Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, Inc., 1981.
- B. Eckes, William and Dan Fulkerson. *Air Conditioning and Refrigeration Book IV*. Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, Inc., 1981.
- C. Miles, Lee. *Refrigeration and Air Conditioning*, 2nd ed. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1987.
- D. Zinngarbe, Claude J., *Sheet Metal Blueprint Reading for the Building Trades*. Albany, New York: Delmar Publishers, a division of Litton Educational Publishing, Inc., 1984.

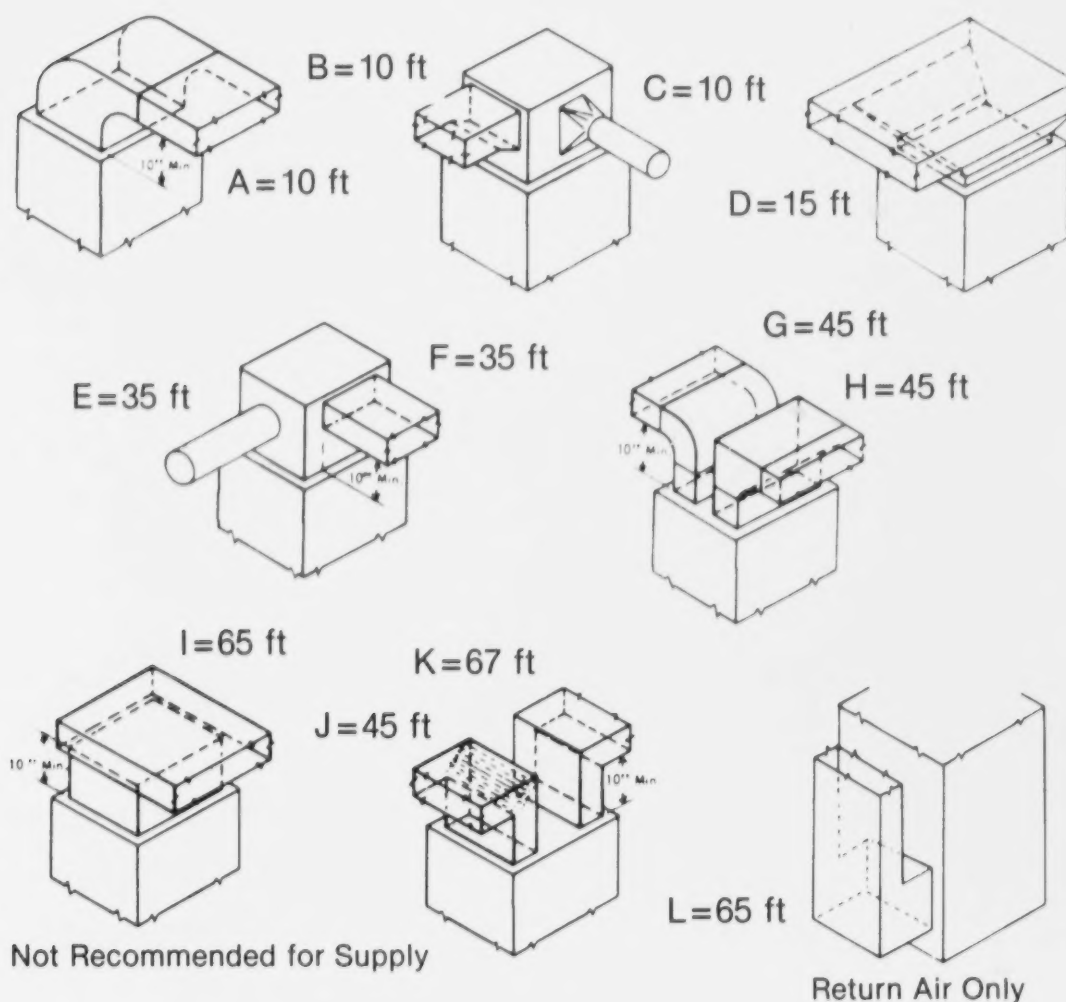


# Duct Fittings and Equivalent Lengths

## (Group 1)

### Supply and Return Air Takeoff Plenum Fittings

(These Fittings May Also be Installed on Plenums for Counter Flow Units.)



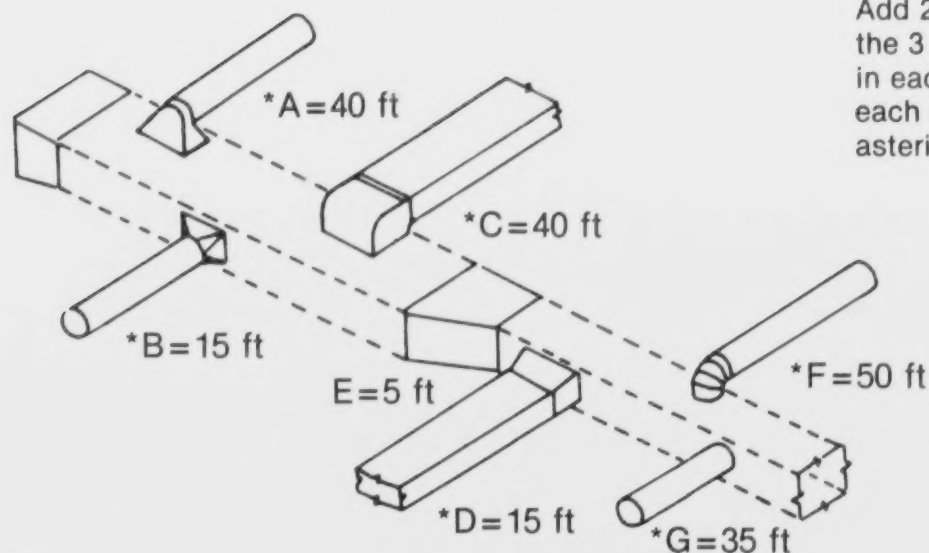
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# Duct Fittings and Equivalent Lengths

(Group 3)

## Extended Plenum Fittings



Add 25 equiv. feet to each of the 3 fittings nearest the unit in each trunk duct and after each reduction as shown by asterisks.

## Drawings of Various Fittings with Equivalent Lengths Shown

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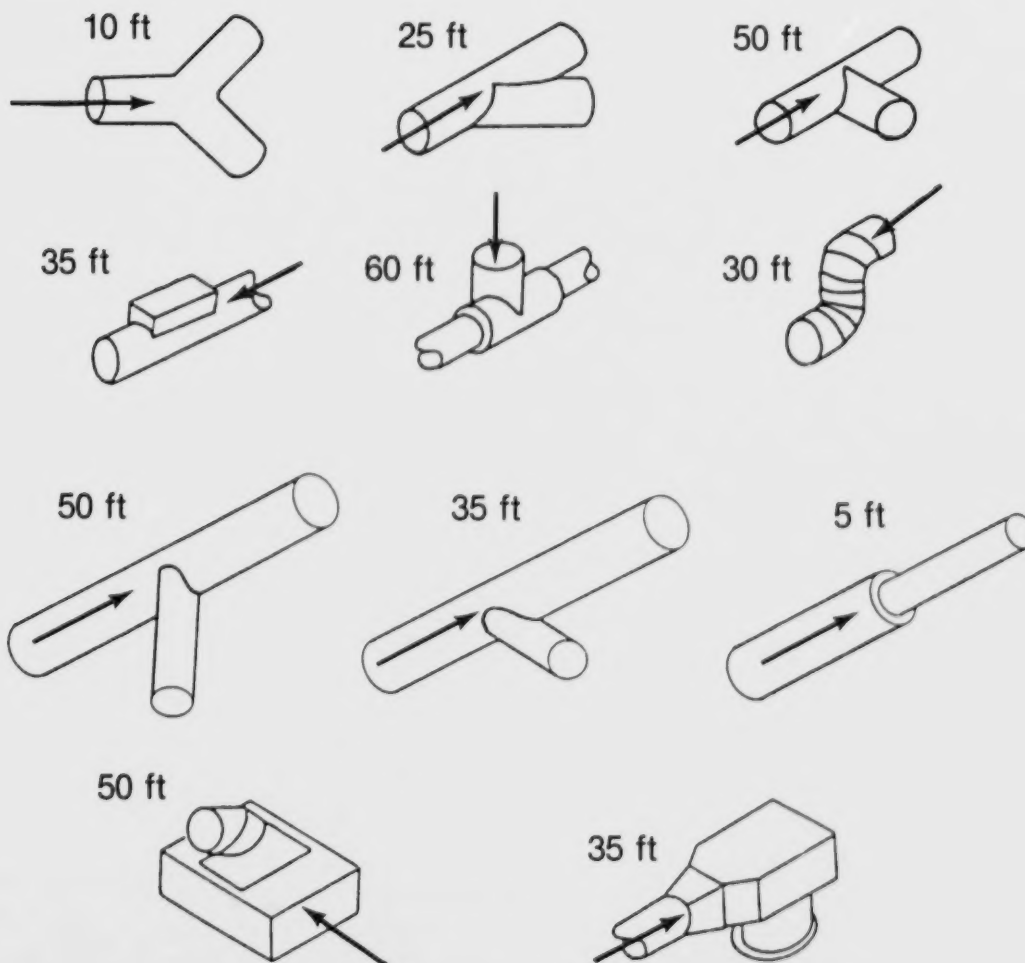


# Duct Fittings and Equivalent Lengths

(Group 4)

## Round Trunk Duct Fittings

(Add 25 equivalent feet to each of the 3 fittings nearest the unit in each trunk duct)



## Drawings of Various Fittings with Equivalent Lengths Shown

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TM #3

# Duct Fittings and Equivalent Lengths

(Group 5)

## Angles and Elbows For Trunk Ducts

(Inside Radius =  $\frac{1}{2}$  Width of Duct)



Trunk Width  
A Inches

4 to 15 = 5 ft  
16 to 27 = 10 ft  
28 to 41 = 15 ft  
42 to 52 = 20 ft  
53 to 63 = 25 ft



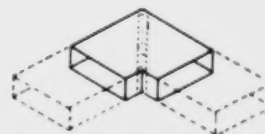
Trunk Width  
B Inches

4 to 11 = 10 ft  
12 to 21 = 15 ft  
22 to 27 = 20 ft  
28 to 33 = 25 ft  
34 to 42 = 30 ft  
43 to 51 = 40 ft  
52 to 64 = 50 ft



Trunk Width  
C Inches

4 to 6 = 20 ft  
7 to 11 = 40 ft  
12 to 15 = 55 ft  
16 to 21 = 75 ft  
22 to 27 = 100 ft  
28 to 33 = 125 ft  
34 to 42 = 150 ft



Trunk Width  
D Inches

4 to 11 = 15 ft  
12 to 21 = 20 ft  
22 to 27 = 25 ft  
28 to 42 = 40 ft



E = 5 ft



F = 10 ft



G = 30 ft



H = 15 ft



I = 30 ft

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# Duct Fittings and Equivalent Lengths

## (Group 6)

### Angles and Elbow For Individual and Branch Ducts

Inside Radius for "A" and "B" = 3 in.  
and for "F" and "G" = 5 in.



A=5 ft



B=10 ft



C=25 ft



D=5 ft



E=10 ft



F=5 ft



G



H



I



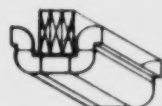
J

10 in. wide=10 ft  
12 =15 ft  
14 =15 ft

10 in. wide=40 ft  
12 =55 ft  
14 =55 ft

3 1/4 x 10 in.=60 ft  
12 =75 ft  
14 =75 ft

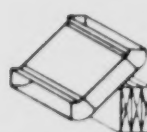
3 1/4 x 10 in.=75 ft  
12 =90 ft  
14 =90 ft



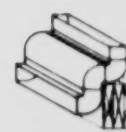
K=125 ft



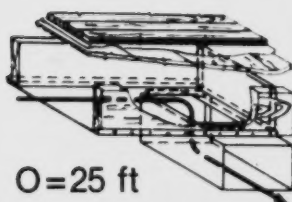
L=35 ft



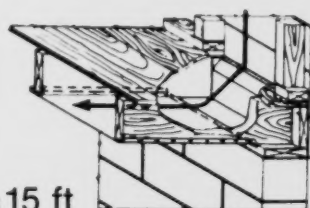
M=10 ft



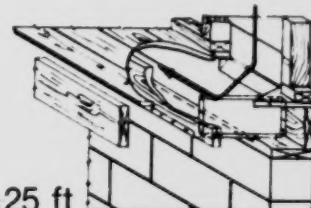
N=95 ft



O=25 ft



P=15 ft



Q=25 ft

Return Air Liner To Duct

Stud Spacer to Liner

Stud Spacer to Liner

### Drawings of Various Fittings with Equivalent Lengths Shown

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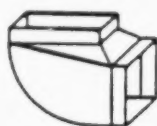
TM #5

# Duct Fittings and Equivalent Lengths (Group 7)

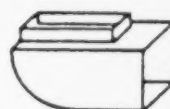
Boot Fittings (These Values may also be Used for Floor Diffuser Boxes)



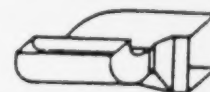
A=30 ft



B=35 ft



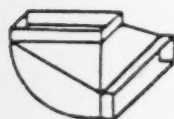
C=60 ft



D=55 ft



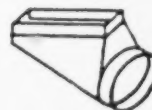
E=70 ft



F=45 ft



G=30 ft



H=50 ft



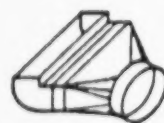
I=5 ft



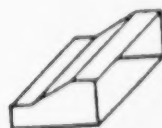
J=15 ft



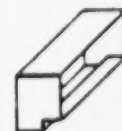
K=30 ft



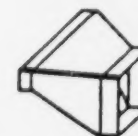
L=30 ft



M=5 ft



N=15 ft



O=5 ft



P=5 ft

Drawings of Various Fittings with Equivalent Lengths Shown

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# Rectangular Duct Equivalents

| Duct Diameter, in. | Equivalent Rectangular Stack and Duct Sizes, in. |       |         |      |      |      |      |      |      |       |       |       |       |
|--------------------|--------------------------------------------------|-------|---------|------|------|------|------|------|------|-------|-------|-------|-------|
| 4.0                |                                                  | 4.5x3 |         |      |      |      |      |      |      |       |       |       |       |
| 4.5                | 8x2.25                                           | 6x3   |         |      |      |      |      |      |      |       |       |       |       |
| 5.0                | 10x2.25                                          |       | 8x3.25  | 5x4  | 4x5  |      |      |      | 3x8  |       |       |       |       |
| 5.5                | 12x2.25                                          |       | 10x3.25 | 7x4  | 5x5  |      |      |      | 4x8  |       |       |       |       |
| 6.0                | 14x2.25                                          |       | 10x3.25 | 8x4  | 6x5  |      |      |      | 4x8  |       |       |       |       |
| 6.5                |                                                  |       | 12x3.25 | 9x4  | 7x5  | 6x6  |      |      | 5x8  |       |       |       |       |
| 7.0                |                                                  |       | 14x3.25 | 11x4 | 8x5  | 7x6  |      |      | 5x8  |       |       |       |       |
| 7.5                |                                                  |       |         | 13x4 | 10x5 | 8x6  | 7x7  |      | 6x8  |       |       |       |       |
| 8.0                |                                                  |       |         | 15x4 | 11x5 | 9x6  | 8x7  |      | 7x8  |       |       |       |       |
| 8.5                |                                                  |       |         | 17x4 | 13x5 | 10x6 | 9x7  | 8x8  |      |       |       |       |       |
| 9.0                |                                                  |       |         | 20x4 | 15x5 | 12x6 | 10x7 | 8x8  |      |       |       |       |       |
| 9.5                |                                                  |       |         | 22x4 | 17x5 | 13x6 | 11x7 | 9x8  | 8x9  |       |       |       |       |
| 10.0               |                                                  |       |         | 25x4 | 19x5 | 15x6 | 12x7 | 11x8 | 9x9  |       |       |       |       |
| 10.5               |                                                  |       |         |      | 21x5 | 16x6 | 14x7 | 12x8 | 10x9 | 9x10  |       |       |       |
| 11.0               |                                                  |       |         |      | 23x5 | 18x6 | 15x7 | 13x8 | 11x9 | 10x10 |       |       |       |
| 11.5               |                                                  |       |         |      | 26x5 | 20x6 | 17x7 | 14x8 | 12x9 | 11x10 |       |       |       |
| 12.0               |                                                  |       |         |      | 29x5 | 22x6 | 18x7 | 16x8 | 14x9 | 12x10 |       |       |       |
| 12.5               |                                                  |       |         |      | 32x5 | 24x6 | 20x7 | 17x8 | 15x9 | 13x10 | 11x12 |       |       |
| 13.0               |                                                  |       |         |      | 35x5 | 27x6 | 22x7 | 18x8 | 16x9 | 14x10 | 12x12 |       |       |
| 13.5               |                                                  |       |         |      |      | 30x6 | 24x7 | 20x8 | 17x9 | 16x10 | 13x12 |       |       |
| 14.0               |                                                  |       |         |      |      | 32x6 | 26x7 | 22x8 | 19x9 | 17x10 | 14x12 |       |       |
| 14.5               |                                                  |       |         |      |      | 35x6 | 28x7 | 24x8 | 20x9 | 18x10 | 15x12 |       |       |
| 15.0               |                                                  |       |         |      |      | 38x6 | 31x7 | 26x8 | 22x9 | 19x10 | 16x12 | 14x14 |       |
| 15.5               |                                                  |       |         |      |      | 41x6 | 33x7 | 28x8 | 24x9 | 21x10 | 17x12 | 14x14 |       |
| 16.0               |                                                  |       |         |      |      | 45x6 | 36x7 | 30x8 | 25x9 | 22x10 | 18x12 | 15x14 |       |
| 16.5               |                                                  |       |         |      |      |      | 38x7 | 32x8 | 27x9 | 24x10 | 19x12 | 16x14 |       |
| 17.0               |                                                  |       |         |      |      |      | 41x7 | 34x8 | 29x9 | 25x10 | 21x12 | 17x14 | 15x16 |
| 17.5               |                                                  |       |         |      |      |      | 44x7 | 37x8 | 31x9 | 27x10 | 22x12 | 18x14 | 16x16 |
| 18.0               |                                                  |       |         |      |      |      |      | 39x8 | 33x9 | 29x10 | 23x12 | 20x14 | 17x16 |
| 18.5               |                                                  |       |         |      |      |      |      | 42x8 | 36x9 | 31x10 | 25x12 | 21x14 | 18x16 |
| 19.0               |                                                  |       |         |      |      |      |      | 45x8 | 38x9 | 33x10 | 26x12 | 22x14 | 19x16 |
| 19.5               |                                                  |       |         |      |      |      |      | 47x8 | 41x9 | 35x10 | 28x12 | 23x14 | 20x16 |
| 20.0               |                                                  |       |         |      |      |      |      | 51x8 | 43x9 | 37x10 | 29x12 | 25x14 | 21x16 |

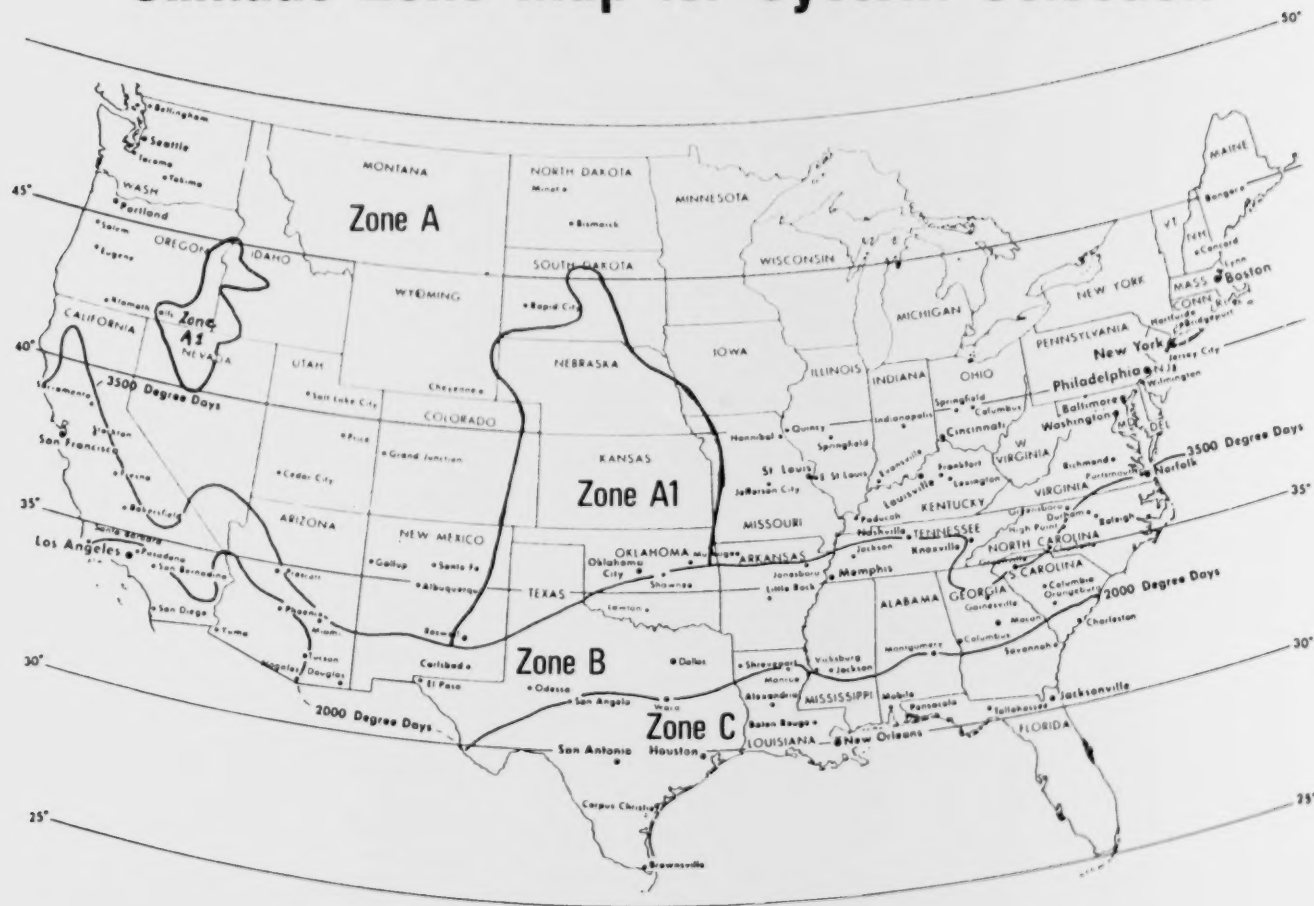
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TM #7



# Climatic Zone Map for System Selection



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TM #8

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ITHVAC-115

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# Friction Loss Per 100 Feet Chart

| Effective Length of Duct (Ft.) | TOTAL PRESSURE DROP IN DUCT (IN. OF WATER) |      |      |      |      |      |      |      |      |
|--------------------------------|--------------------------------------------|------|------|------|------|------|------|------|------|
|                                | 0.05                                       | 0.07 | 0.10 | 0.15 | 0.20 | 0.25 | 0.30 | 0.40 | 0.50 |
| 35-44                          | 0.13                                       | 0.18 | 0.25 | 0.38 | 0.50 | 0.63 | 0.75 | 1.00 | 1.25 |
| 45-54                          | 0.10                                       | 0.14 | 0.20 | 0.30 | 0.40 | 0.50 | 0.60 | 0.80 | 1.00 |
| 55-64                          | 0.08                                       | 0.12 | 0.17 | 0.25 | 0.33 | 0.42 | 0.50 | 0.67 | 0.83 |
| 65-74                          | 0.07                                       | 0.10 | 0.14 | 0.21 | 0.29 | 0.36 | 0.43 | 0.57 | 0.72 |
| 75-84                          | 0.06                                       | 0.09 | 0.13 | 0.19 | 0.25 | 0.31 | 0.38 | 0.50 | 0.63 |
| 85-94                          | 0.06                                       | 0.08 | 0.11 | 0.17 | 0.22 | 0.28 | 0.33 | 0.45 | 0.56 |
| 95-104                         | 0.05                                       | 0.07 | 0.10 | 0.15 | 0.20 | 0.25 | 0.30 | 0.40 | 0.50 |
| 105-114                        | 0.05                                       | 0.06 | 0.09 | 0.14 | 0.18 | 0.23 | 0.28 | 0.37 | 0.46 |
| 115-129                        | 0.04                                       | 0.06 | 0.08 | 0.12 | 0.17 | 0.21 | 0.25 | 0.33 | 0.47 |
| 130-149                        | 0.04                                       | 0.05 | 0.07 | 0.11 | 0.14 | 0.18 | 0.21 | 0.29 | 0.36 |
| 150-169                        | 0.03                                       | 0.04 | 0.06 | 0.09 | 0.13 | 0.16 | 0.19 | 0.25 | 0.31 |
| 170-189                        | 0.03                                       | 0.04 | 0.06 | 0.08 | 0.11 | 0.14 | 0.17 | 0.22 | 0.28 |
| 190-214                        | 0.03                                       | 0.04 | 0.05 | 0.08 | 0.10 | 0.13 | 0.15 | 0.20 | 0.25 |
| 215-239                        | 0.02                                       | 0.03 | 0.05 | 0.07 | 0.09 | 0.11 | 0.13 | 0.18 | 0.22 |
| 240-264                        | 0.02                                       | 0.03 | 0.04 | 0.06 | 0.08 | 0.10 | 0.12 | 0.16 | 0.20 |
| 265-289                        | 0.02                                       | 0.03 | 0.04 | 0.05 | 0.07 | 0.09 | 0.11 | 0.15 | 0.18 |
| 290-324                        | 0.02                                       | 0.03 | 0.03 | 0.05 | 0.07 | 0.08 | 0.10 | 0.13 | 0.17 |
| 325-374                        | 0.02                                       | 0.02 | 0.03 | 0.04 | 0.06 | 0.07 | 0.09 | 0.11 | 0.14 |
| 375-424                        | 0.01                                       | 0.02 | 0.03 | 0.04 | 0.05 | 0.06 | 0.08 | 0.10 | 0.13 |
| 425-474                        | 0.01                                       | 0.02 | 0.03 | 0.03 | 0.05 | 0.06 | 0.07 | 0.09 | 0.11 |
| 475-524                        | 0.01                                       | 0.02 | 0.02 | 0.03 | 0.04 | 0.05 | 0.06 | 0.08 | 0.10 |
| 525-574                        | 0.01                                       | 0.01 | 0.02 | 0.03 | 0.04 | 0.05 | 0.06 | 0.07 | 0.09 |
| 575-625                        | 0.01                                       | 0.01 | 0.02 | 0.03 | 0.03 | 0.04 | 0.05 | 0.07 | 0.08 |

Table for converting system design pressure (total pressure drop in duct) and total effective length of duct to friction loss per 100 ft.

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## Suggested Static Pressures for Duct Design

| Available External Pressure (in W.G.) | .12 | .15 | .20            | .25 | .30 | .40 |
|---------------------------------------|-----|-----|----------------|-----|-----|-----|
| Use for Supply                        | .07 | .10 | (* .15)<br>.10 | .15 | .20 | .30 |
| Multiple Return                       | .05 | .05 | .10            | .10 | .10 | .10 |
| Simple Return                         | .05 | .05 | .05            | .10 | .10 | .10 |

### \*Simple Return

Pressures included in this table are suggested for most typical installations. Other pressures may be used when desired. Be certain that duct system pressure plus pressure loss of cooling coil, all accessories, etc., do not exceed the available static pressure of unit selected.

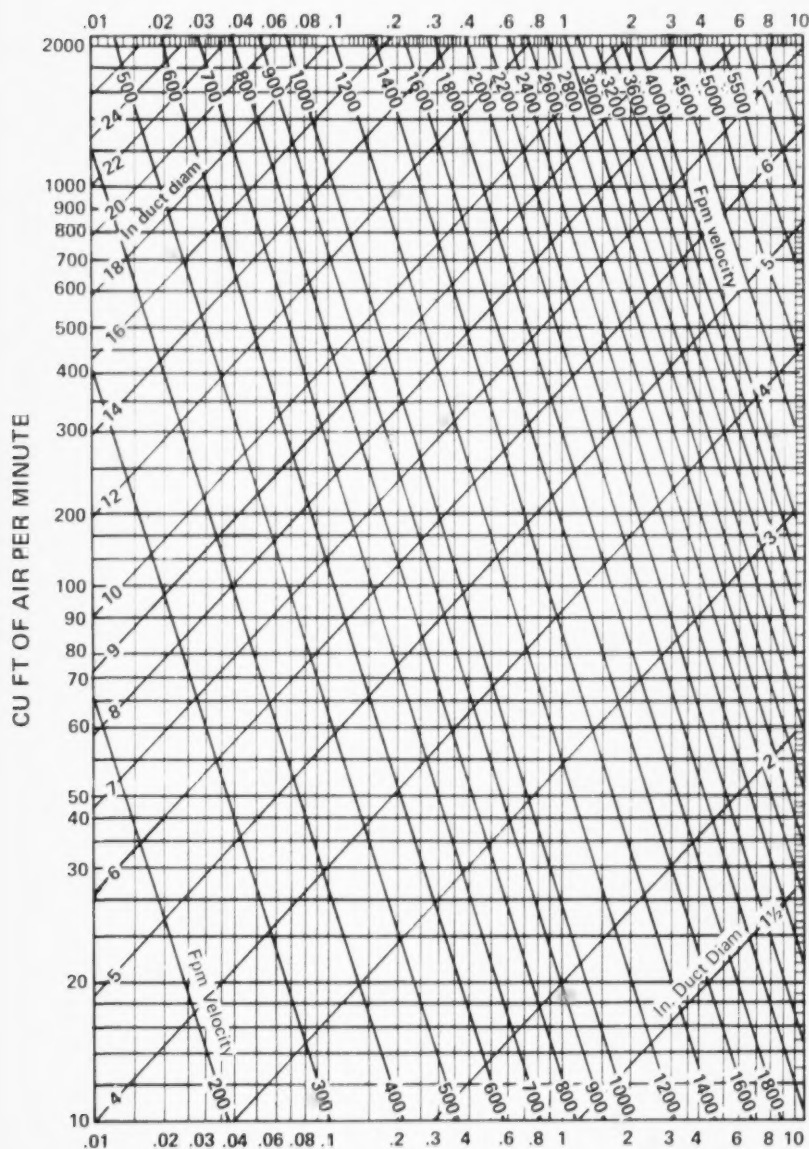
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TM #10

# Friction Chart



## Friction Loss in Inches of Water Per 100 Ft

(Based on Standard Air of 0.075 lb per cu ft density flowing through average, clean round, galvanized metal ducts having approximately 40 joints per 100 ft.)

Caution: Do not extrapolate below chart.

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TM #11

HVAC LAYOUT  
UNIT III

## INFORMATION SHEET

## I. Terms and definitions associated with HVAC layout

- A. **Warm-air heating system** — A combination of a furnace, ducts, and controls put together in such a way as to deliver warm air to all parts of a structure so that a comfortable living condition exists
- B. **Plenum** — First fitting or air chamber off the heating or cooling unit which receives the air delivery from the fan and distributes it in the trunkline
- C. **Crawl space** — Narrow space between a floor unit and the ground
- D. **Hydronics** — The science of heating with water
- E. **Radiant heat** — A system in which only the heat radiated from panels is effective in providing the heating requirements
- F. **Static pressure (sp)** — A measure of the resistance of ducts, grilles, filters, and other surfaces to the flow of air; this is the pressure within ductwork, which is positive if the duct is a supply duct and negative if the duct is a return duct
- G. **Equivalent length** — Resistance to air flow created by the structural design of a fitting and indicated by the length of straight duct that would offer the same resistance
- H. **System pressure** — Sum of the negative and positive static pressures being exerted by a blower
- I. **cfm** — Cubic feet per minute
- J. **fpm** — Feet per minute
- K. **Terminal velocity** — An arbitrary maximum velocity of an air stream which spreads or drops into a living area, usually considered comfortable at 35-50 fpm
- L. **Takeoff** — The point of departure from a duct to which a duct fitting is attached to accomplish branching of ductwork
- M. **Btuh** — British thermal units per hour
- N. **iwg** — Inches water gauge



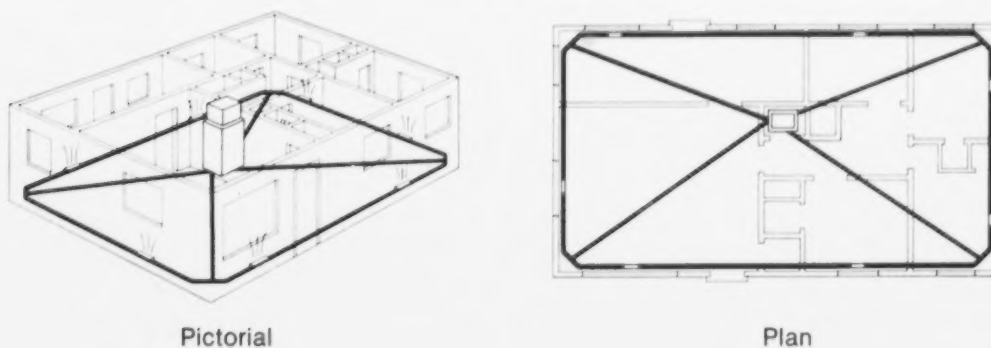
## INFORMATION SHEET

## II. Types of warm-air heating systems

## A. Loop perimeter system (Figure 1)

(NOTE: In this system, the supply duct is installed in a continuous, closed loop around the perimeter of the building. The supply air passes from a centrally located furnace or air-conditioner plenum to the perimeter loop through several feeder ducts, which are usually evenly spaced along the loop or are designed to enter the loop at the point in the room where warm air is needed most.)

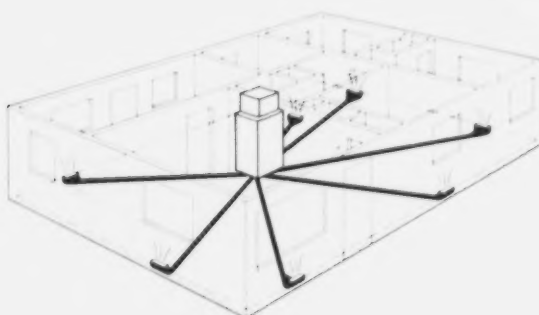
FIGURE 1



## B. Radial perimeter system (Figure 2)

(NOTE: In this system, the supply air is delivered from a central plenum in separate ducts running from the plenum to each outlet in all directions. Because of this, this system is suitable only for crawl space or slab construction.)

FIGURE 2



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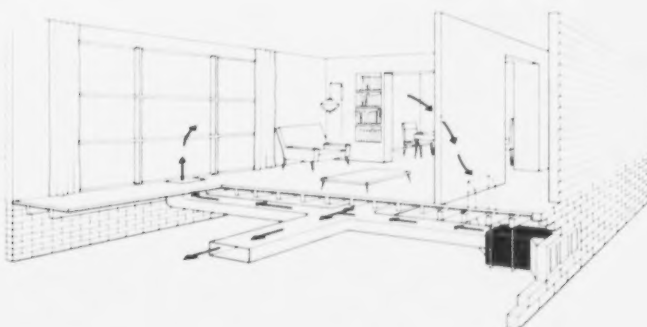


## INFORMATION SHEET

## C. Crawl space plenum system (Figure 3)

(NOTE: In this system, the entire crawl space acts as a plenum and the air supply passes to the outlets which are cut in the floor between studs.)

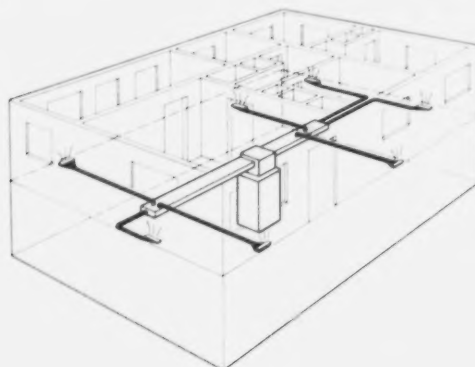
FIGURE 3



## D. Extended plenum system (Figure 4)

(NOTE: In this system, the plenum may extend from one or both sides of the heating or cooling source and is usually located along the center of the structure, sometimes the full length of the structure. As in the radial system, the air supply is delivered in several ducts, taking off at various points along the plenum and extending to each outlet. The supply ducts can be installed between the joist to permit more headroom in a basement installation. This system may be used in basements, crawl space, or attics.)

FIGURE 4



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## INFORMATION SHEET

## E. Graduated trunk system

(NOTE: The graduated trunk system is considered the finest of all warm-air heating systems. This system can be used on all types of basement installations.)

FIGURE 5

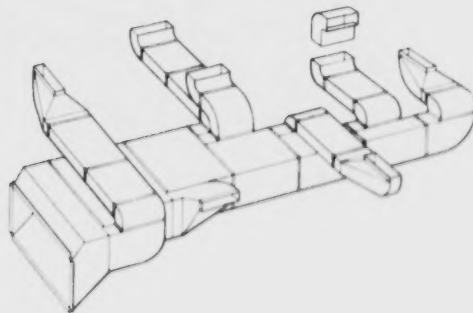


Figure 5 reproduced by permission. SHEETMETAL BLUEPRINT READING FOR THE BUILDING TRADES by Claude J. Zinngabe. Delmar Publishers Inc., © 1980.

## III. Types of fuels used as the principal means of domestic heat

- |         |                |         |
|---------|----------------|---------|
| A. Coal | C. Gas         | E. Wood |
| B. Oil  | D. Electricity |         |

## IV. Methods of delivery for warm-air heating systems

- A. Gravity
- B. Forced

## V. Advantages of the forced-air system

(NOTE: The forced-air system is used more today.)

- |                     |                             |
|---------------------|-----------------------------|
| A. Smaller ducts    | D. Filtered air             |
| B. Quicker heat     | E. Humidified air           |
| C. Flexible control | F. Positive air circulation |



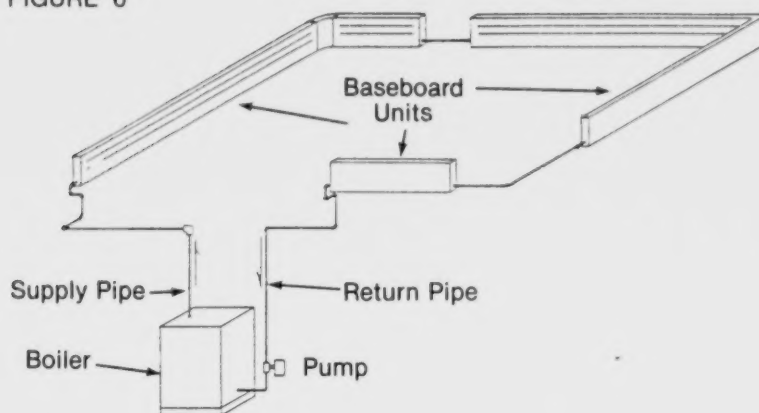
## INFORMATION SHEET

## VI. Common hydronic system designs

## A. Series loop system (Figure 6)

(NOTE: This is a single circuit system which makes one continuous loop, from the boiler, around the perimeter of the structure, passing through the baseboard units and back to the boiler. This system has a low installation cost.)

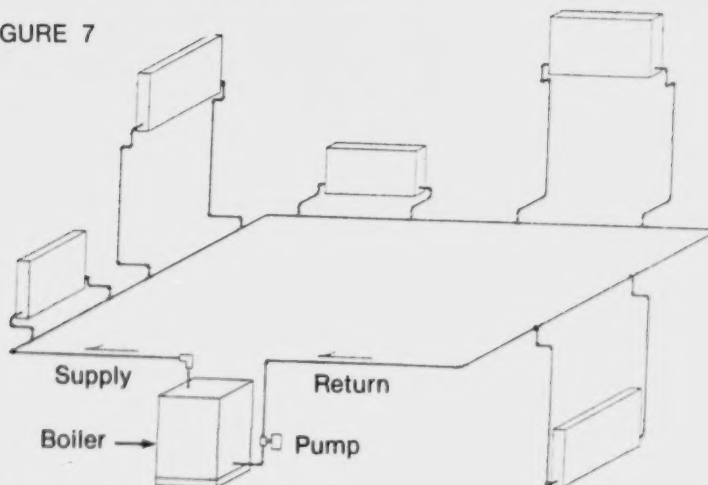
FIGURE 6



## B. One-pipe system (Figure 7)

(NOTE: This is a single circuit system which makes a loop around the perimeter of the structure with individual terminal units connected to the loop by smaller pipes and hydronic fittings; with this system it is possible to control flow and heat from individual terminal units.)

FIGURE 7



Figures 6 and 7 used with permission of NHAW Home Study Institute, Columbus, Ohio.

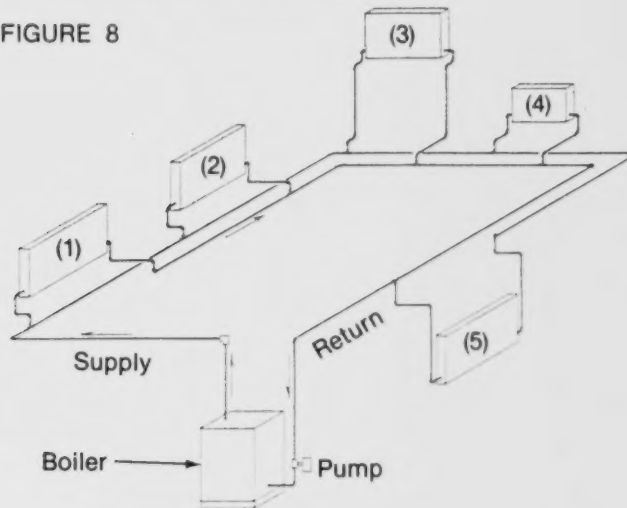


## INFORMATION SHEET

## C. Two-pipe reverse return system (Figure 8)

(NOTE: This system has a common supply loop to all terminal units in the circuit and has a separate circuit of return water from the terminal units in reverse order from the supply.)

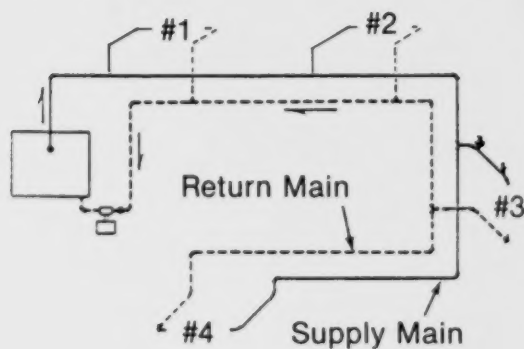
FIGURE 8



## D. Two-pipe direct return system (Figure 9)

(NOTE: In this system the supply pipe ends at the farthest terminal unit and the return pipe starts at the farthest terminal unit. This system is valuable in a split system [dual temperature] and costs less than a reverse return system.)

FIGURE 9



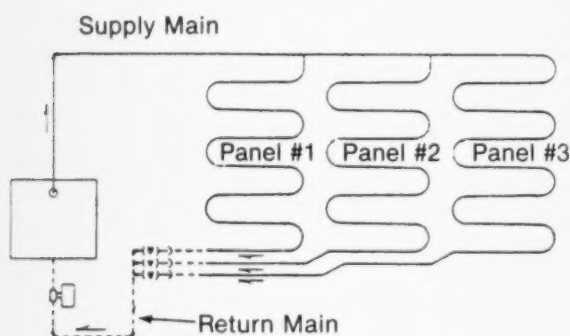
Figures 8 and 9 used with permission of NHAW Home Study Institute, Columbus, Ohio.

## INFORMATION SHEET

## E. Panel system (Figure 10)

(NOTE: Panel systems are built into the floor or ceiling and use radiant heat; all coils feed off of the main supply and the return pipes all feed into the return main. This system does not interfere with placement of furniture and equipment.)

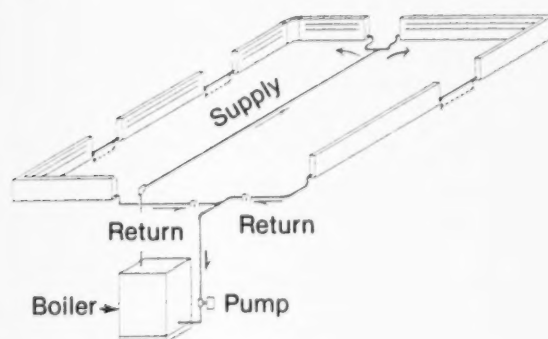
FIGURE 10



## F. Multiple circuit system (Figures 11a and 11b)

(NOTE: Multiple circuit systems can be used on any other types of system. With this system the total length of circuits is reduced, number of terminal units in a circuit is reduced, and paper size of main trunk pipe is reduced.)

FIGURE 11a

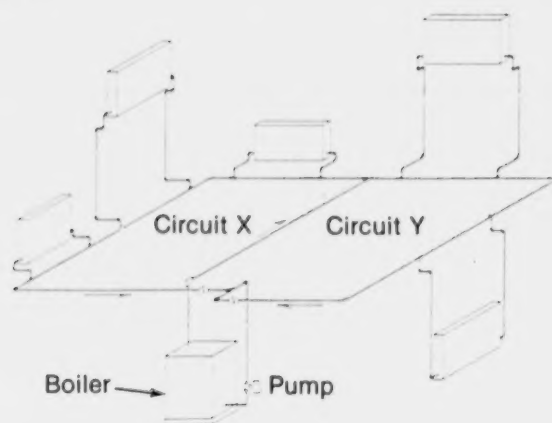


Series loop baseboard system

Figures 10 and 11 used with permission of NHAW Home Study Institute, Columbus, Ohio.

## INFORMATION SHEET

FIGURE 11b



One-pipe forced hot water heating system

Figure 11b used with permission of NHAW Home Study Institute, Columbus, Ohio.

## VII. Basic types of hydronic systems

### A. Gravity system

(NOTE: Hydronic gravity systems are seldom used in the United States.)

1. Operates on the principle that hot water is lighter than cold water

(NOTE: The difference between the weight of hot water and the weight of cold water is expressed in mill inches [.001 in.] per foot of height.)

2. Head seldom exceeds 3 to 4 inches
3. Requires much larger pipe system, often up to 2 1/2 inches

### B. Forced circulation system

(NOTE: Because of their advantages, forced circulation systems have replaced gravity systems in the United States.)

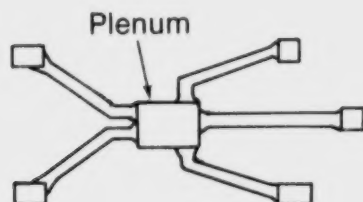
1. Operates on pump pressure
2. Head may be 8 to 15 feet
3. Frequently uses 3/4-inch pipe and sometimes 1/2-inch pipe
4. When tankless water heater is present, provision must be made to prevent gravity effect during off cycle

## INFORMATION SHEET

## VIII. Types of supply duct systems

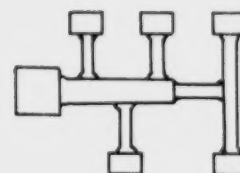
A. Radial or spider (Figure 12)

FIGURE 12



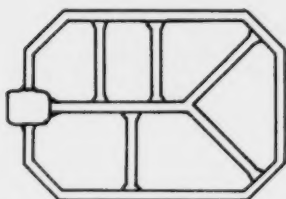
B. Trunk and branch reducing plenum (Figure 13)

FIGURE 13



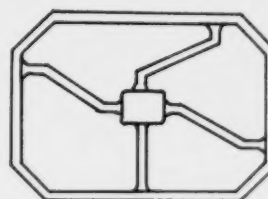
C. Perimeter loop trunk duct (Figure 14)

FIGURE 14



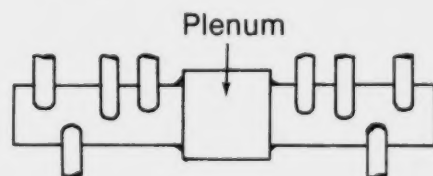
D. Perimeter loop radial duct (Figure 15)

FIGURE 15



E. Trunk and branch extended plenum (Figure 16)

FIGURE 16



Figures 12 through 16 used with permission of Air-Conditioning Contractors of America, Washington, D.C.



## INFORMATION SHEET

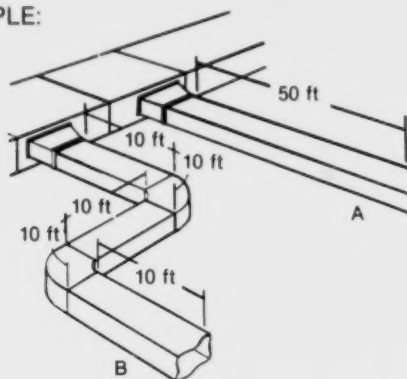
## IX. Factors affecting system design and the effects that they have on the system

## A. Duct length

1. Volume — Greater duct length reduces volume of air to be delivered
2. Pressure — Greater duct length increases static pressure and resistance to air flow
3. Duct gain or loss — Greater duct length increases temperature of cold air or reduces temperature of warm air passing through the duct

## B. Equivalent length — Changes in shape or direction of ducts will reduce volume of air flow because of increased resistance caused by air flow friction

## EXAMPLE:



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## C. Effective length (See example)

1. Prime factor used to determine duct diameter for a given pressure in a system
2. Determined by adding the actual ductwork length plus the equivalent length of fittings

## D. System pressure

1. Prime factor used to determine duct diameter for a given air volume in a system
2. Selection is made after determining capability of equipment blower
3. Apportioned between supply ducts and return ducts

## E. Design air volume

1. Transmits the total heat available from the heat source proportional to the amount of air delivered

## INFORMATION SHEET

2. When heating, the temperature will rise if the amount of air is reduced, and the temperature will fall if the amount of air is increased
- F. Pressure drop per 100 feet — Affects the selection of the duct diameter; if the factor is too small, the duct diameter will be too large
- G. Temperature rise
1. A decrease in air volume will result in an increase in temperature rise
  2. An increase in air volume will result in a decrease in temperature rise
- H. Duct wrap (insulation) — Reduces heat loss or heat gain in duct and eliminates condensation
- I. Supply outlets — Size, design, and location affect the efficiency of the system and degree of comfort
- X. Major steps in air system design and procedures to follow in completing each step
- A. Select air distribution system
1. Determine climatic region
  2. Determine design of structure
  3. Determine location of ducts
  4. Determine best type of distribution system
- B. Select heating and cooling equipment
1. Calculate total system load
  2. Calculate heating and cooling cfm
  3. Determine appropriate type of equipment to be used
  4. Select proper sized unit for heating
  5. Select condensing unit and evaporator coil for cooling
  6. Determine location of condensing unit, heating equipment, and thermostat
- C. Lay out and size ductwork
1. Determine appropriate location of ductwork
  2. Calculate number of outlet and inlet openings





## INFORMATION SHEET

3. Calculate the cfm required for each outlet
  4. Determine the type of duct to be used and draw the runs
  5. Obtain the equivalent lengths of fittings
  6. Determine the total effective length of ducts
  7. Determine the external static pressure drop per 100 feet
  8. Size duct using appropriate chart
- D. Select registers and grilles for supply and return air
1. Examine floor plan to determine appropriate outlet register
  2. Select appropriate registers based on correct distribution patterns
  3. Select the proper return air grille size
- XI. Factors affecting return-air duct design
- A. Return-air inlets are not normally placed in a kitchen or bathroom
  - B. An optimum system has a return-air inlet in each bedroom
  - C. Return-air inlets are normally placed so that air is not dragged over 30 feet from a supply
  - D. Return-air duct system must be designed for a design air volume equal to or greater than the supply air volume
  - E. Return-air inlets should be placed on every level of a split-level structure
- (NOTE: In two-story residences and split-level houses with only one system, the upstairs return-air system should be oversized by at least 10%; in small ranch houses, 1600 sq. ft. or less, a simple one-return trunk duct is adequate.)
- F. Combined return-air pressure and supply pressure must not exceed total available static pressure of the blower.
- (NOTE: Return design pressure is usually 0.1 inch static pressure (sp) or less to allow greater pressure to be used in supply system.)
- G. Return-air inlets are usually placed on inside walls which allows shorter duct-work
- XII. Locations of registers and grilles
- A. Perimeter (radial, loop, or trunk and branch)
  - B. High inside wall
  - C. Low inside wall
  - D. Ceiling



## INFORMATION SHEET

## XIII. Climatic zone conditions

## A. Zone A

1. Cold weather is more severe and more prolonged
2. Summers are relatively mild

## B. Zone B

1. Less severe winters than zone A
2. Hotter days for extended periods

## C. Zone C

1. Has mild winters
2. Has hot summers

## D. Zone A-1

Has the characteristics of zone A except that summer temperatures are, on the average, higher than zone A

(NOTE: The Air Conditioning Contractors of America (ACCA) have three comfort ratings for air conditioning systems; the recommended level will provide occupants basic comfort requirements, the next lowest rating is acceptable, but the lowest rating is not acceptable.)

EXAMPLE: A high inside wall supply is recommended in zone C, acceptable in zone B, but not acceptable in zones A-1 or A

## XIV. Factors to consider in distribution of conditioned air

## A. Velocity of primary air

## B. Desired temperature of room air

## C. Proper sizing and location of grilles and registers to minimize noise and discomfort from drafts

## D. Velocity of air in duct system

1. Trunk duct — 1000 fpm
2. Branch duct — 500-750 fpm

(NOTE: Because the sensation of drafts is greater with cold air, velocities of 25 to 35 fpm are recommended for an occupied space, but velocities from 20 to 50 fpm are acceptable; velocities lower than 15 fpm create stagnant air, and velocities over 65 fpm create uncomfortable drafts.)



## INFORMATION SHEET

- XV. Significant room air patterns as determined by outlet placement and their recommended velocities

(NOTE: These room air patterns have been determined by research conducted at the University of Illinois.)

- A. Floor diffusers — 450 fpm
- B. Baseboard diffusers — 700 fpm
- C. High sidewall registers — 350-500 fpm
- D. Low sidewall registers — 500 fpm

(NOTE: Inadequate velocity from any diffuser or register will cause primary cold air to drop into occupied space before reaching terminal velocity.)

- XVI. Instructions for using friction loss per 100 feet chart (Assignment Sheet #1)

(NOTE: The friction chart and friction loss per 100 ft. chart were developed by the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) for use by all air conditioning and heating contractors. The charts for 10 cfm to 2000 cfm will cover all residential situations.)

- A. Obtain the available static pressure from the furnace nameplate or manufacturer's data
- B. Take available static pressure and apportion for supply and return duct system (Transparency #10)
- C. Locate the supply or return static pressure at the top of the friction loss per 100 ft. chart

(NOTE: This procedure will apply to supply and return static pressure.)

- D. Determine the effective length of the first duct and locate on left side of friction loss per 100 ft. chart
- E. Find the intersection of the column and row on the chart to determine friction loss per 100 ft. of the first duct
- F. Repeat steps D and E for each remaining duct

- XVII. Instructions for using the friction chart (Assignment Sheet #2)

- A. Obtain the friction loss per 100 ft. for the first duct
- B. Locate the friction loss per 100 ft. at the bottom of the friction chart
- C. Follow the friction loss line upward to its intersection with the desired cfm (from plans)
- D. Select the larger duct size of the two possible sizes as indicated on the chart

## INFORMATION SHEET

- E. Select the air velocity at this intersection with the size of duct selected and cfm desired

(NOTE: The round ducts commonly used in residential applications are available commercially in even inches through 8" diameter; 9" round ducts are seldom used in modern construction, and large ducts are available only in even inches of diameter. Rectangular ducts may be built to any size.)



# HVAC LAYOUT UNIT III

## ASSIGNMENT SHEET #1 — SOLVE PROBLEMS USING THE FRICTION LOSS PER 100 FEET CHART

NAME \_\_\_\_\_

SCORE \_\_\_\_\_

Directions: Using the friction loss per 100 ft. chart (Transparency #9) select the friction loss per 100 ft. of effective length when given the effectiveness length and the pressure drop.

|     | Effective<br>Length | Pressure<br>Drop | Friction Loss<br>per 100 ft. |
|-----|---------------------|------------------|------------------------------|
| 1.  | 180                 | 0.20             | _____                        |
| 2.  | 125                 | 0.20             | _____                        |
| 3.  | 220                 | 0.20             | _____                        |
| 4.  | 45                  | 0.20             | _____                        |
| 5.  | 440                 | 0.20             | _____                        |
| 6.  | 350                 | 0.40             | _____                        |
| 7.  | 220                 | 0.25             | _____                        |
| 8.  | 140                 | 0.15             | _____                        |
| 9.  | 90                  | 0.10             | _____                        |
| 10. | 500                 | 0.50             | _____                        |
| 11. | 400                 | 0.40             | _____                        |
| 12. | 300                 | 0.30             | _____                        |
| 13. | 200                 | 0.20             | _____                        |
| 14. | 100                 | 0.10             | _____                        |
| 15. | 100                 | 0.20             | _____                        |
| 16. | 100                 | 0.30             | _____                        |
| 17. | 100                 | 0.40             | _____                        |
| 18. | 100                 | 0.50             | _____                        |



# HVAC LAYOUT UNIT III

## ASSIGNMENT SHEET #2 — SOLVE PROBLEMS USING THE FRICTION CHART

NAME \_\_\_\_\_ SCORE \_\_\_\_\_

Directions: Find duct size and velocity of air in ducts using the friction chart. (Transparency #11)

|     | CFM  | Friction Loss<br>per 100 ft. | Duct<br>Diameter | Velocity<br>Ft/Min |
|-----|------|------------------------------|------------------|--------------------|
| 1.  | 98   | 0.02                         | _____            | _____              |
| 2.  | 210  | 0.03                         | _____            | _____              |
| 3.  | 125  | 0.08                         | _____            | _____              |
| 4.  | 400  | 0.20                         | _____            | _____              |
| 5.  | 500  | 0.20                         | _____            | _____              |
| 6.  | 55   | 0.07                         | _____            | _____              |
| 7.  | 80   | 0.15                         | _____            | _____              |
| 8.  | 500  | 5.00                         | _____            | _____              |
| 9.  | 100  | 0.60                         | _____            | _____              |
| 10. | 1400 | 0.15                         | _____            | _____              |
| 11. | 1000 | 0.02                         | _____            | _____              |
| 12. | 500  | 0.03                         | _____            | _____              |
| 13. | 200  | 0.05                         | _____            | _____              |
| 14. | 2000 | 3.50                         | _____            | _____              |



# HVAC LAYOUT UNIT III

## ASSIGNMENT SHEET #3 — DESIGN AN AIR DISTRIBUTION SYSTEM FROM A DRAWING

NAME \_\_\_\_\_ SCORE \_\_\_\_\_

- A. Make a single line scale drawing of the desired supply and return duct system (Figures 1 and 2)

- B. Select adequate heating and/or cooling equipment from manufacturer's catalog

(NOTE: The output capacity of the equipment must conform to local codes.)

- C. Determine total available external static pressure and cfm of equipment blower from equipment nameplate or manufacturer's literature

EXAMPLE: External sp 0.05 iwg expressed on nameplate  
CFM 1200 @ 0.03 iwg expressed in literature

- D. Apportion pressure drop to supply and return duct systems (TM #10)

- E. Determine cfm per Btuh heating

EXAMPLE:  $\frac{800 \text{ cfm}}{80,000 \text{ Btuh output}} = .01 \text{ cfm/Btuh}$

- F. Determine temperature rise

EXAMPLE: Furnace output in Btuh divided by cfm  $\times 1.1$

$\frac{80,000}{800 \times 1.1} = 90.9 \text{ degrees temperature rise}$

(NOTE: In psychometric calculations the factor 1.08 has been used for many years. ASHRAE has recently recommended that this factor be changed to 1.1)

- G. Determine cfm per Btuh cooling

(NOTE: System design in cooling is nearly always 400 cfm per 12,000 Btuh cooling, therefore the cfm per Btuh will consistently be 0.033.)

- H. Multiply each room heat loss by cfm per Btuh heating to determine cfm per room, heating

- I. Multiply each room heat gain by cfm per Btuh cooling to determine cfm per room, cooling

- J. Select the larger cfm as the minimum air volume for each room

- K. Determine number of outlets for each room and apportion cfm to each outlet if more than one is required (Figure 3)



## ASSIGNMENT SHEET #3



FIGURE 1

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## ASSIGNMENT SHEET #3

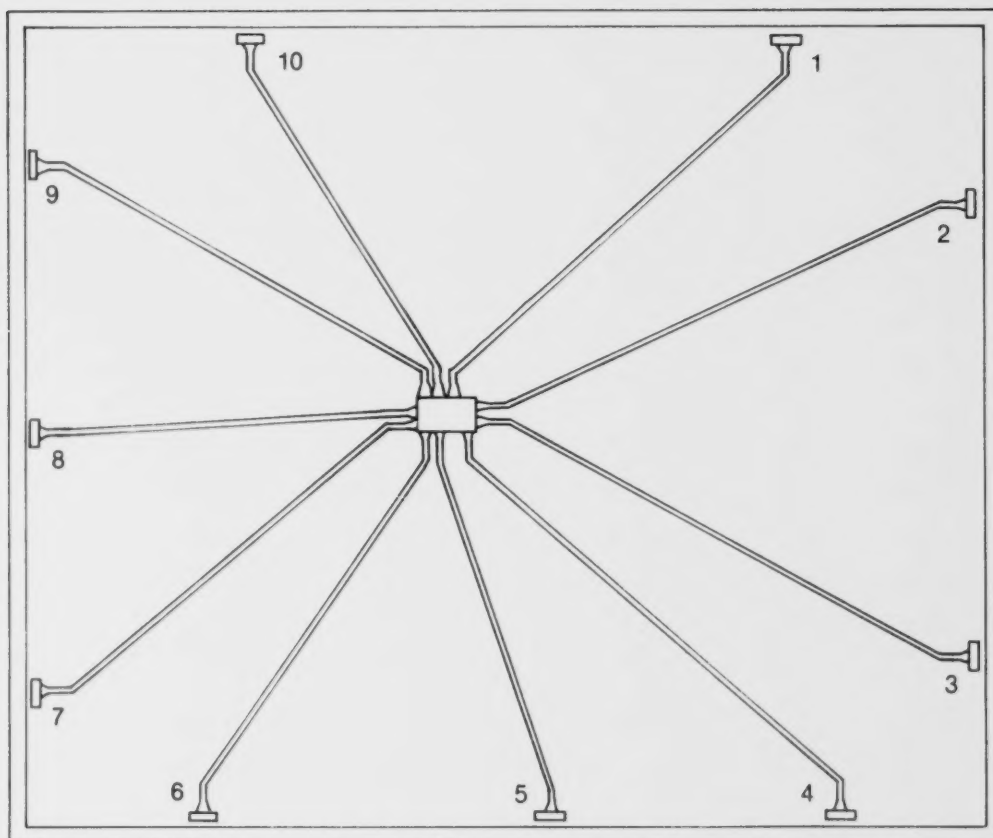


FIGURE 2

Used with permission of Air-Conditioning Contractors of America, Washington, D.C.





## ASSIGNMENT SHEET #3

Recommended Maximum Air Volumes for Common Sizes of  
Residential Type Registers and Diffusers

| ROUND<br>DUCT<br>DIAMETER | HIGH<br>OR<br>LOW<br>WALL<br>REGISTER | FLOOR<br>DIFFUSER | ROUND<br>CEILING<br>DIFFUSER | RECOMM.<br>MAXIMUM<br>CFM |
|---------------------------|---------------------------------------|-------------------|------------------------------|---------------------------|
| 6"                        | 10" x 6"                              | 10" x 4"          | 6"                           | 100—110 CFM               |
| 7"                        | 12" x 6"                              | 12" x 4"          | 7"                           | 150—160 CFM               |
| 8"                        | 14" x 6"                              | 14" x 4"          | 8"                           | 200—215 CFM               |

FIGURE 3

- L. Measure actual length of each duct from scale drawing
- M. List duct fittings and equivalent lengths of fittings (TM #1 through TM #7)
  - 1. Do not include register or grille
  - 2. Use plenum fitting for all ducts which take off at plenum
  - 3. Add equivalent lengths in each duct and record
- N. Add measure length to equivalent length and record total effective length of each duct
- O. Select friction loss per 100 ft. for each duct (TM #9) using proper pressure drop from step D
- P. Select diameter of round duct and velocity for each duct from friction chart (TM #11)
- Q. Repeat steps K through P for return-duct system using return-air pressure drop from step D
- R. Determine rectangular duct or well stack if required (TM #7)
- S. Determine required registers and grilles

## ASSIGNMENT SHEET #3

1. Use manufacturer's catalog sheets
2. Static pressure of registers and grilles are not to exceed 0.03 iwg

## SPECIFICATIONS

|                                         |                                 |
|-----------------------------------------|---------------------------------|
| Outside design temperature:             | 10 degrees                      |
| Daily temperature range:                | Medium                          |
| Ducts located in ventilated crawl space |                                 |
| Duct insulation:                        | 1" flexible duct wrap           |
| Total heat loss:                        | 49,900 Btuh                     |
| Total heat gain:                        | 17,600 Btuh                     |
| Equipment selected:                     | 60,000 Btuh input gas furnace   |
|                                         | 18,000 Btuh air conditioner     |
| Equipment blower:                       | 600 cfm at 0.15 static pressure |
| Return air system:                      | Simple return                   |

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## ASSIGNMENT SHEET #3

Specifications: Equivalent Length of Fittings

|       |      |       |      |       |      |       |      |       |      |
|-------|------|-------|------|-------|------|-------|------|-------|------|
| 1     |      | 2     |      | 3     |      | 4     |      | 5     |      |
| FTG.  | E.L. | FTG.  | E.L. | FTG.  | E.L. | FTG.  | E.L. | FTG.  | E.L. |
| 1-E   |      | 1-E   |      | 1-E   |      | 1-E   |      | 1-E   |      |
| 6-D   |      | 6-D   |      | 6-D   |      | 6-D   |      | 6-D   |      |
| 6-E   |      | 6-E   |      | 6-E   |      | 6-E   |      | 6-E   |      |
| 7-I   |      | 7-I   |      | 7-I   |      | 7-I   |      | 7-I   |      |
| Total |      | Total |      | Total |      | Total |      | Total |      |

|       |      |       |      |       |      |       |      |       |      |
|-------|------|-------|------|-------|------|-------|------|-------|------|
| 6     |      | 7     |      | 8     |      | 9     |      | 10    |      |
| FTG.  | E.L. | FTG.  | E.L. | FTG.  | E.L. | FTG.  | E.L. | FTG.  | E.L. |
| 1-E   |      | 1-E   |      | 1-E   |      | 1-E   |      | 1-E   |      |
| 6-D   |      | 6-D   |      | 6-D   |      | 6-D   |      | 6-D   |      |
| 6-E   |      | 6-E   |      | 6-E   |      | 6-E   |      | 6-E   |      |
| 7-I   |      | 7-I   |      | 7-I   |      | 7-I   |      | 7-I   |      |
|       |      | 7-N   |      |       |      | 6-E   |      |       |      |
|       |      |       |      |       |      | 7-G   |      |       |      |
|       |      |       |      |       |      | 7-N   |      |       |      |
| Total |      | Total |      | Total |      | Total |      | Total |      |

(NOTE: All references to fittings are by group number and item number. 1-E means E from group 1, 6-D means item D from group 6, etc. Check the appropriate transparency master before making calculations.)

# ASSIGNMENT SHEET #3

JOB NAME \_\_\_\_\_ SUPPLY STATIC PRESSURE \_\_\_\_\_ IWG CFM PER BTU HEATING \_\_\_\_\_  
 DATE Complete this form RETURN STATIC PRESSURE \_\_\_\_\_ IWG CFM PER BTU COOLING 0.033  
 FURNACE OUTPUT 48000 BLOWER CFM \_\_\_\_\_ TOTAL EXTERNAL STATIC PRESS \_\_\_\_\_ Temp. Rise \_\_\_\_\_

| Room       | Heat Loss | CFM Htg | Heat gain | CFM Cooling | Outlet # | CFM | Meas. Length | Equiv. Length | Eft. Length | Press Drop per 100 ft. | Duct Diameter | Velocity |
|------------|-----------|---------|-----------|-------------|----------|-----|--------------|---------------|-------------|------------------------|---------------|----------|
| Living     | 12,500    |         | 4,000     |             | 1        |     | 15           |               |             |                        |               |          |
| "          |           |         |           |             | 2        |     | 20           |               |             |                        |               |          |
| Kitchen    | 10,800    |         | 3,900     |             | 3        |     | 25           |               |             |                        |               |          |
| "          |           |         |           |             | 4        |     | 15           |               |             |                        |               |          |
| Dining     | 5,000     |         | 2,200     |             | 5        |     | 12           |               |             |                        |               |          |
| Bedroom #1 | 8,700     |         | 2,200     |             | 6        |     | 15           |               |             |                        |               |          |
| "          |           |         |           |             | 7        |     | 20           |               |             |                        |               |          |
| Bath       | 3,500     |         | 700       |             | 8        |     | 8            |               |             |                        |               |          |
| Bedroom #2 | 9,400     |         | 2,300     |             | 9        |     | 25           |               |             |                        |               |          |
| "          |           |         |           |             | 10       |     | 10           |               |             |                        |               |          |

ASSIGNMENT SHEET #3

ITHVAC-149



HVAC LAYOUT  
UNIT III

## ANSWERS TO ASSIGNMENT SHEETS

## ASSIGNMENT SHEET #1

|    |      |     |      |
|----|------|-----|------|
| 1. | 0.11 | 10. | 0.10 |
| 2. | 0.17 | 11. | 0.10 |
| 3. | 0.09 | 12. | 0.10 |
| 4. | 0.40 | 13. | 0.10 |
| 5. | 0.05 | 14. | 0.10 |
| 6. | 0.11 | 15. | 0.20 |
| 7. | 0.11 | 16. | 0.30 |
| 8. | 0.11 | 17. | 0.40 |
| 9. | 0.11 | 18. | 0.50 |

## ASSIGNMENT SHEET #2

|    |    |      |     |    |      |
|----|----|------|-----|----|------|
| 1. | 8  | 275  | 8.  | 5  | 4000 |
| 2. | 10 | 400  | 9.  | 5  | 1100 |
| 3. | 7  | 500  | 10. | 24 | 450  |
| 4. | 9  | 1000 | 11. | 20 | 500  |
| 5. | 10 | 1100 | 12. | 14 | 500  |
| 6. | 5  | 400  | 13. | 9  | 475  |
| 7. | 5  | 600  | 14. | 9  | 4500 |



## ANSWERS TO ASSIGNMENT SHEETS

## ASSIGNMENT SHEET #3

|       |      |       |      |       |      |       |      |       |      |
|-------|------|-------|------|-------|------|-------|------|-------|------|
| 1     |      | 2     |      | 3     |      | 4     |      | 5     |      |
| FTG.  | E.L. | FTG.  | E.L. | FTG.  | E.L. | FTG.  | E.L. | FTG.  | E.L. |
| 1-E   | 35   | 1-E   | 35   | 1-E   | 35   | 1-E   | 35   | 1-E   | 35   |
| 6-D   | 5    | 6-D   | 5    | 6-D   | 5    | 6-D   | 5    | 6-D   | 5    |
| 6-E   | 10   | 6-E   | 10   | 6-E   | 10   | 6-E   | 10   | 6-E   | 10   |
| 7-I   | 5    | 7-I   | 5    | 7-I   | 5    | 7-I   | 5    | 7-I   | 5    |
| Total | 55   | Total | 55   | Total | 55   | Total | 55   | Total | 55   |

|       |      |       |      |       |      |       |      |       |      |
|-------|------|-------|------|-------|------|-------|------|-------|------|
| 6     |      | 7     |      | 8     |      | 9     |      | 10    |      |
| FTG.  | E.L. | FTG.  | E.L. | FTG.  | E.L. | FTG.  | E.L. | FTG.  | E.L. |
| 1-E   | 35   | 1-E   | 35   | 1-E   | 35   | 1-E   | 35   | 1-E   | 35   |
| 6-D   | 5    | 6-D   | 5    | 6-D   | 10   | 6-D   | 10   | 6-D   | 5    |
| 6-E   | 10   | 6-E   | 10   | 6-E   | 30   | 6-E   | 10   | 6-E   | 10   |
| 7-I   | 5    | 7-I   | 30   | 7-I   | 15   | 7-I   | 10   | 7-I   | 5    |
|       |      | 7-N   | 15   |       |      | 6-E   | 10   |       |      |
|       |      |       |      |       |      | 7-G   | 30   |       |      |
|       |      |       |      |       |      | 7-N   | 15   |       |      |
| Total | 55   | Total | 95   | Total | 85   | Total | 120  | Total | 55   |

(NOTE: All references to fittings are by group number and item number. 1-E means E from group 1, 6-D means item D from group 6, etc. Check the appropriate transparency master before making calculations.)

# ANSWERS TO ASSIGNMENT SHEET #3

JOB NAME SHEET #3 SUPPLY STATIC PRESSURE        IWG CFM PER BTU HEATING         
 DATE        RETURN STATIC PRESSURE        IWG CFM PER BTU COOLING 0.033  
 FURNACE OUTPUT 48000 BLOWER CFM        TOTAL EXTERNAL  
 STATIC PRESS .151 IWG Temp. Rise       

| Room       | Heat Loss | CFM Htg | Heat gain | CFM Cooling | Outlet # | CFM | Meas. Length | Equiv. Length | Eff. Length | Press Drop per 100 ft. | Duct Diameter | Velocity |
|------------|-----------|---------|-----------|-------------|----------|-----|--------------|---------------|-------------|------------------------|---------------|----------|
| Living     | 12,500    | 156     | 4,000     | 132         | 1        | 78  | 15           | 55            | 70          | 0.14                   | 5             | 600      |
| "          | "         |         |           |             | 2        | 78  | 20           | 55            | 75          | 0.13                   | 5             | 550      |
| Kitchen    | 10,800    | 135     | 3,900     | 129         | 3        | 68  | 25           | 55            | 80          | 0.13                   | 5             | 550      |
| "          | "         |         |           |             | 4        | 68  | 15           | 55            | 70          | 0.14                   | 5             | 550      |
| Dining     | 5,000     | 63      | 2,200     | 73          | 5        | 73  | 12           | 55            | 67          | 0.14                   | 5             | 600      |
| Bedroom #1 | 8,700     | 108     | 2,200     | 73          | 6        | 54  | 15           | 15            | 70          | 0.14                   | 5             | 550      |
| "          | "         |         |           |             | 7        | 54  | 20           | 95            | 100         | 0.10                   | 5             | 550      |
| Bath       | 3,500     | 44      | 700       | 23          | 8        | 44  | 8            | 85            | 93          | 0.11                   | 5             | 450      |
| Bedroom #2 | 9,400     | 117     | 2,300     | 76          | 9        | 59  | 25           | 120           | 145         | 0.07                   | 6             | 300      |
| "          | "         |         |           |             | 10       | 59  | 10           | 55            | 65          | 0.14                   | 5             | 450      |





# HVAC LAYOUT UNIT III

## TEST

NAME \_\_\_\_\_

SCORE \_\_\_\_\_

1. Match terms associated with HVAC layout to their correct definitions. Write the correct numbers in the blanks.

- |                                                                                                                                                                                                                                        |                            |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------|
| _____ a. A combination of a furnace, ducts, and controls put together in such a way as to deliver warm air to all parts of a structure so that a comfortable living condition exists                                                   | 1. Radiant heat            |
| _____ b. First fitting or air chamber off the heating or cooling unit which receives the air delivery from the fan and distributes it in the trunkline                                                                                 | 2. Terminal velocity       |
| _____ c. Narrow space between a floor unit and the ground                                                                                                                                                                              | 3. cfm                     |
| _____ d. The science of heating with water                                                                                                                                                                                             | 4. Crawl space             |
| _____ e. A system in which only the heat radiated from panels is effective in providing the heating requirements                                                                                                                       | 5. Equivalent length       |
| _____ f. A measure of the resistance of ducts, grilles, filters, and other surfaces to the flow of air; this is the pressure within ductwork, which is positive if the duct is a supply duct and negative if the duct is a return duct | 6. fpm                     |
| _____ g. Resistance to air flow created by the structural design of a fitting and indicated by the length of straight duct that would offer the same resistance                                                                        | 7. Warm-air heating system |
| _____ h. Sum of the negative and positive static pressures being exerted by a blower                                                                                                                                                   | 8. Btuh                    |
| _____ i. Cubic feet per minute                                                                                                                                                                                                         | 9. Static pressure (sp)    |
| _____ j. Feet per minute                                                                                                                                                                                                               | 10. Hydronics              |
| _____ k. British thermal units per hour                                                                                                                                                                                                | 11. Takeoff                |
| _____ l. An arbitrary maximum velocity of an air stream which spreads or drops into a living area, usually considered comfortable at 35-50 fpm                                                                                         | 12. Plenum                 |
|                                                                                                                                                                                                                                        | 13. System pressure        |
|                                                                                                                                                                                                                                        | 14. iwg                    |



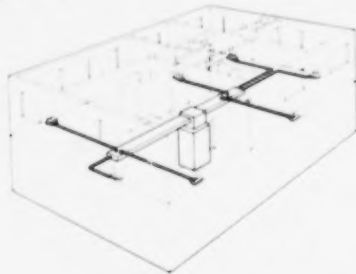


## TEST

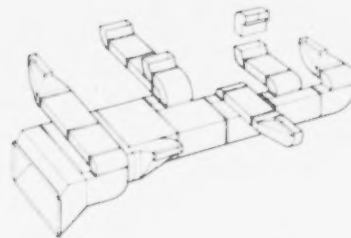
\_\_\_\_m. The point of departure from a duct to which a duct fitting is attached to accomplish branching of ductwork

\_\_\_\_n. Inches water gauge

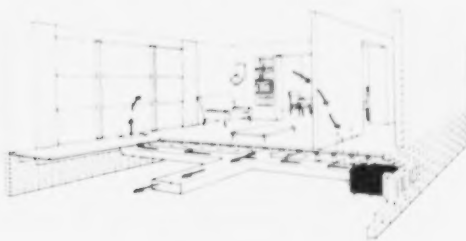
2. Label the following illustrations of warm-air heating systems. Write their correct names in the blanks.



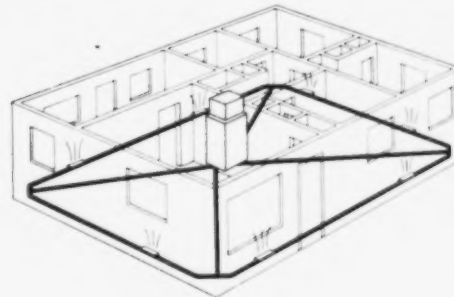
a. \_\_\_\_\_



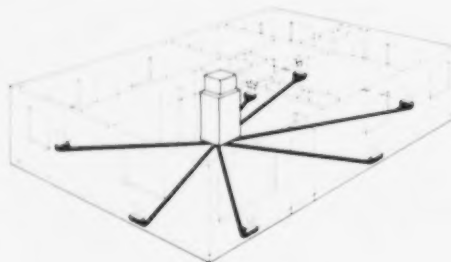
b. \_\_\_\_\_



c. \_\_\_\_\_



d. \_\_\_\_\_

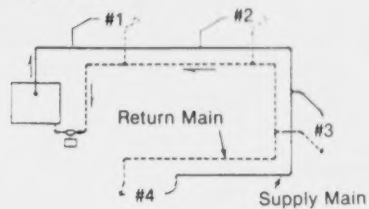


e. \_\_\_\_\_

## TEST

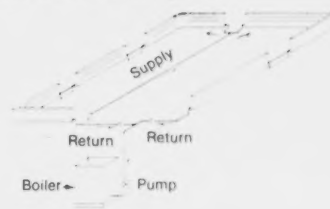
3. Name three types of fuels used as the principal means of domestic heat.
- a. \_\_\_\_\_
- b. \_\_\_\_\_
- c. \_\_\_\_\_
4. Name the two methods of delivery for warm-air heating systems.
- a. \_\_\_\_\_
- b. \_\_\_\_\_
5. Select advantages of the forced-air system. Place an "X" in the blanks before the correct answers.
- |                                   |                          |
|-----------------------------------|--------------------------|
| _____ a. Humidified air           | _____ e. More air volume |
| _____ b. Flexible control         | _____ f. Quicker heat    |
| _____ c. Less ductwork            | _____ g. Smaller ducts   |
| _____ d. Positive air circulation | _____ h. Filtered air    |
6. Identify the following designs of common hydronic systems. Write their correct names in the blanks.

**One-pipe system**  
**Multiple circuit system**  
**Series loop system**

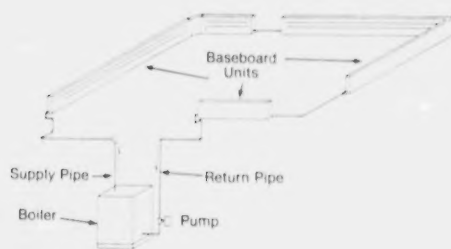


a. \_\_\_\_\_

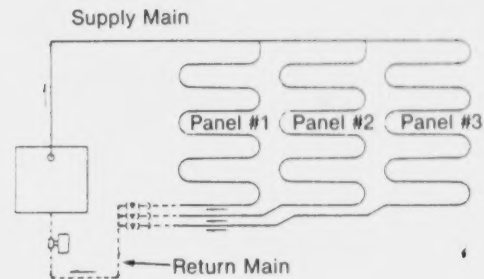
**Two-pipe direct return system**  
**Panel system**  
**Two-pipe reverse return system**



b. \_\_\_\_\_

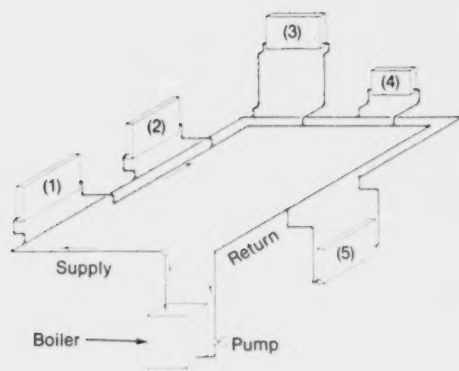


c. \_\_\_\_\_

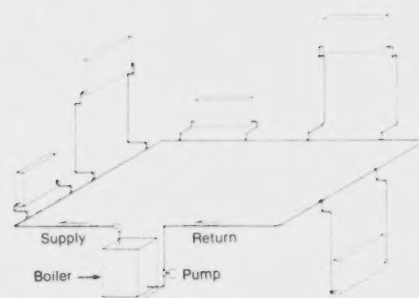


d. \_\_\_\_\_

## TEST



e. \_\_\_\_\_



f. \_\_\_\_\_

7. Distinguish between the two basic types of hydronic systems. Write the correct answers in the blanks.

## a. Gravity system

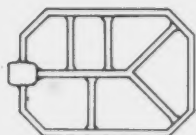
1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_

## b. Forced circulation system

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_

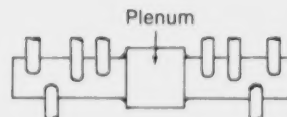
8. Identify the following illustrations of types of supply duct systems. Write their correct names in the blanks.

Trunk and branch reducing plenum  
Trunk and branch extended plenum  
Radial or spider



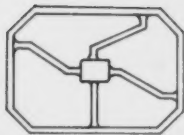
a. \_\_\_\_\_

Perimeter loop radial duct  
Perimeter loop trunk duct

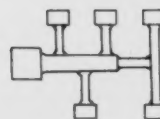


b. \_\_\_\_\_

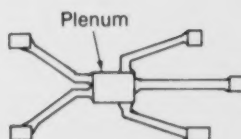
## TEST



c. \_\_\_\_\_



d. \_\_\_\_\_



e. \_\_\_\_\_

9. Match the factors affecting system design with the effects they have on the system. Write the correct number in the blanks.

- |          |                                                                                                                                          |                               |
|----------|------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|
| _____ a. | 1) Volume — Greater duct length reduces volume of air to be delivered                                                                    | 1. Effective length           |
|          | 2) Pressure — Greater duct length increases static pressure and resistance to air flow                                                   | 2. Temperature rise           |
|          | 3) Duct gain or loss — Greater duct length increases temperature of cold air or reduces temperature of warm air passing through the duct | 3. Design air volume          |
|          |                                                                                                                                          | 4. Duct wrap (insulation)     |
|          |                                                                                                                                          | 5. Duct length                |
|          |                                                                                                                                          | 6. System pressure            |
| _____ b. | Changes of shape or direction of ducts will reduce volume of air flow because of increased resistance caused by air flow friction        | 7. Supply outlets             |
|          |                                                                                                                                          | 8. Equivalent length          |
| _____ c. | 1) Prime factor used to determine duct diameter for a given pressure in a system                                                         | 9. Pressure drop per 100 feet |
|          | 2) Determined by adding the actual ductwork length plus the equivalent length of fittings                                                |                               |
| _____ d. | 1) Prime factor used to determine duct diameter for a given air volume in a system                                                       |                               |
|          | 2) Selection is made after determining capability of equipment blower                                                                    |                               |
|          | 3) Apportioned between supply ducts and return ducts                                                                                     |                               |



## TEST

- \_\_\_\_e. 1) Transmits the total heat available from the heat source proportional to the amount of air delivered
- 2) When heating, the temperature will rise if the amount of air is reduced, and the temperature will fall if the amount of air is increased
- \_\_\_\_f. Affects the selection of duct diameter; if factor is too small, the duct diameter will be too large
- \_\_\_\_g. 1) A decrease in air volume will result in an increase in temperature rise
- 2) An increase in air volume will result in a decrease in temperature rise
- \_\_\_\_h. Reduces heat loss or heat gain in duct and eliminates condensation
- \_\_\_\_i. Size, design, and location affect the efficiency of the system and degree of comfort
10. Match major steps in air system design to the procedures to follow in completing each step. Write the correct numbers in the blanks.
- |                                                                             |                                                           |
|-----------------------------------------------------------------------------|-----------------------------------------------------------|
| ____a. 1) Calculate total system load                                       | 1. Select registers and grilles for supply and return air |
| 2) Calculate heating and cooling cfm                                        |                                                           |
| 3) Determine appropriate type of equipment to be used                       | 2. Lay out and size duct work                             |
| 4) Select proper size unit for heating                                      | 3. Select heating and cooling equipment                   |
| 5) Select condensing unit and evaporator coil for cooling                   | 4. Select air distribution system                         |
| 6) Determine location of condensing unit, heating equipment, and thermostat |                                                           |
| ____b. 1) Examine floor plan to determine appropriate outlet register       |                                                           |
| 2) Select appropriate registers based on correct distribution patterns      |                                                           |
| 3) Select the proper return-air grille size                                 |                                                           |
| ____c. 1) Determine climatic region                                         |                                                           |
| 2) Determine design of structure                                            |                                                           |
| 3) Determine location of ducts                                              |                                                           |
| 4) Determine heat type of distribution system                               |                                                           |

## TEST

- \_\_\_\_\_d. 1) Determine appropriate location of ductwork
- 2) Calculate number of outlet and inlet openings
- 3) Calculate the cfm required for each outlet
- 4) Determine the type of duct to be used and draw the runs
- 5) Obtain the equivalent lengths of fittings
- 6) Determine the total effective length of ducts
- 7) Determine the external static pressure drop per 100 feet
- 8) Size duct using appropriate chart
11. Select factors affecting return air duct design. Place an "X" in the blanks before the correct answers.
- \_\_\_\_\_a. Return-air inlets are normally placed within 60 feet of the supply
- \_\_\_\_\_b. Return-air inlets should be placed on every level of a split-level structure
- \_\_\_\_\_c. Return-air inlets are not normally placed in a kitchen or bathroom
- \_\_\_\_\_d. Return-air inlets are normally placed so that air is not dragged over 30 feet from a supply
- \_\_\_\_\_e. Return-air duct systems must be designed for a design air volume equal to or greater than the supply air volume
- \_\_\_\_\_f. Return-air duct systems must be designed for a design air volume equal to or less than the supply air volume
- \_\_\_\_\_g. Place a return air inlet on only the upper level of a split-level structure
- \_\_\_\_\_h. An optimum system has a return-air inlet in each bedroom
- \_\_\_\_\_i. Return-air inlets are usually placed on inside walls which allows shorter duct work
12. List three locations of registers and grilles.
- a. \_\_\_\_\_
- b. \_\_\_\_\_
- c. \_\_\_\_\_



## TEST

13. Briefly describe climatic zone conditions. Write the correct answers in the blanks.

a. Zone A

1) \_\_\_\_\_

2) \_\_\_\_\_

b. Zone B

1) \_\_\_\_\_

2) \_\_\_\_\_

c. Zone C

1) \_\_\_\_\_

2) \_\_\_\_\_

d. Zone A-1

\_\_\_\_\_

14. Name four factors to consider in the distribution of conditioned air. Write the correct answers in the blanks.

a. \_\_\_\_\_

\_\_\_\_\_

b. \_\_\_\_\_

\_\_\_\_\_

c. \_\_\_\_\_

\_\_\_\_\_

d. \_\_\_\_\_

\_\_\_\_\_

15. Match these significant room air patterns as determined by outlet placement to their recommended velocities. Write the correct numbers in the blanks.

\_\_\_\_\_ a. Floor diffusers

1. 700 fpm

\_\_\_\_\_ b. Baseboard diffusers

2. 350-500 fpm

\_\_\_\_\_ c. High sidewall registers

3. 500 fpm

\_\_\_\_\_ d. Low sidewall registers

4. 450 fpm

## TEST

(NOTE: Test questions 16, 17, and 18 list the assignment sheets which are an important part of this test. If they have not been completed, check with your instructor.)

16. Solve problems using the friction loss per 100 feet chart.
17. Solve problems using the friction chart.
18. Design an air distribution system from a drawing.

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# HVAC LAYOUT UNIT III

## ANSWERS TO TEST

1.   a. 7                      d. 10                      g. 5                      j. 6                      m. 11  
      b. 12                  e. 1                      h. 13                  k. 8                      n. 14  
      c. 4                      f. 9                      i. 3                      l. 2
  
2.   a. Extended plenum system                      d. Loop perimeter system  
      b. Graduated trunk system                      e. Radial perimeter system  
      c. Crawl space plenum system
  
3.   Answer should include any three of the following.  
      a. Coal                  c. Gas                      e. Wood  
      b. Oil                   d. Electricity
  
4.   Answer should include the following.  
      a. Gravity  
      b. Forced
  
5.   a, b, d, f, g, h
  
6.   a. Two-pipe direct return system                      d. Panel system  
      b. Multiple circuit system                      e. Two-pipe reverse return system  
      c. Series loop system                      f. One-pipe system
  
7.   Answer should include the following.  
      a. Gravity system  
          1. Operates on the principle that hot water is lighter than cold water  
          2. Head seldom exceeds 3 to 4 inches  
          3. Requires much larger pipe system, often up to 2 1/2 inches  
  
      b. Forced circulation system  
          1. Operates on pump pressure  
          2. Head may be 8 to 15 feet  
          3. Frequently uses 3/4-inch pipe and sometimes 1/2-inch pipe  
          4. When tankless water heater is present, provision must be made to prevent gravity effect during off cycle



## ANSWERS TO TEST

8. a. Perimeter loop trunk duct  
b. Trunk and branch extended plenum  
c. Perimeter loop radial duct  
d. Trunk and branch reducing plenum  
e. Radial or spider
9. a. 5                      d. 6                      g. 2  
b. 8                      e. 3                      h. 4  
c. 1                      f. 9                      i. 7
10. a. 3                      c. 4  
b. 1                      d. 2
11. b, c, d, e, h, i
12. Answer should include any three of the following.  
a. Perimeter (radial, loop or trunk and branch)  
b. High inside wall  
c. Low inside wall  
d. Ceiling
13. Answer should include the following.  
a. Zone A  
1) Cold weather is more severe and more prolonged  
2) Summers are relatively mild  
b. Zone B  
1) Less severe winters than Zone A  
2) Hotter days for extended periods  
c. Zone C  
1) Has mild winters  
2) Has hot summers  
d. Zone A-1  
Has the characteristics of Zone A except that summer temperatures are, on the average, higher than Zone A
14. Answer should include the following.  
a. Velocity of primary air  
b. Desired temperature of room air  
c. Proper sizing and location of grilles and registers to minimize noise and discomfort from drafts  
d. Velocity of air in duct system  
1. Trunk ducts — 1000 fpm  
2. Branch ducts — 500-750 fpm

## ANSWERS TO TEST

15. a. 4                      c. 2  
      b. 1                    d. 3
16. Evaluated to the satisfaction of the instructor.
17. Evaluated to the satisfaction of the instructor.
18. Evaluated to the satisfaction of the instructor.



HVAC BASIC SKILLS  
UNIT IV

## UNIT OBJECTIVE

After completing this unit, the student should be able to perform basic skills used in HVAC operations. The student will show this ability by completing job sheets and unit test with a minimum score of 80 percent.

## SPECIFIC OBJECTIVES

After completing this unit, the student should be able to

1. Match terms associated with HVAC basic skills to their correct definitions.
2. Name types of HVAC units.
3. Name major components of a forced-air gas furnace.
4. Name major components of a forced-air oil furnace system.
5. Name major components of an electric forced-air system.
6. Name major components of a heat pump.
7. Name major components of a hydronic system.
8. Name major components of a cooling system.
9. Select basic skills used in HVAC operations.
10. Determine pipe lengths and fittings necessary to connect a gas furnace.
11. Determine lengths of PVC and fittings necessary to construct a condensate line.
12. Demonstrate ability to
  - a. Make a flare with compression-type flaring block.
  - b. Make a flare with generating-type flaring block.
  - c. Make a swage joint.
  - d. Make a 90-degree bend in copper tubing.
  - e. Make a 180-degree bend in copper tubing.
  - f. Make a 45-degree offset bend in copper tubing.



## OBJECTIVE SHEET

- g. Cut, ream, and join copper tubing using a flare joint.
- h. Cut, ream, and join copper tubing using the compression method.
- i. Cut, ream, and join copper tubing using the sweat method.
- j. Cut, ream, and join copper tubing using the swage method.
- k. Construct a tubing project.
- l. Measure and mark a predetermined length of pipe.
- m. Cut, ream, and thread a piece of one-inch steel pipe.
- n. Cut, ream, and join plastic pipe.

HVAC BASIC SKILLS  
UNIT IV

SUGGESTED ACTIVITIES

I. Unit contents

- A. Objective sheet
- B. Suggested activities
- C. Information sheet
- D. Assignment sheets
  - 1. Assignment Sheet #1 — Determine Pipe Lengths and Fittings Necessary to Connect a Gas Furnace
  - 2. Assignment Sheet #2 — Determine Lengths of PVC and Fittings Necessary to Construct a Condensate Line
- E. Answers to assignment sheets
- F. Job sheets
  - 1. Job Sheet #1 — Make a Flare with Compression-Type Flaring Block
  - 2. Job Sheet #2 — Make a Flare with Generating-Type Flaring Block
  - 3. Job Sheet #3 — Make a Swage Joint
  - 4. Job Sheet #4 — Make a 90-Degree Bend in Copper Tubing
  - 5. Job Sheet #5 — Make a 180-Degree Bend in Copper Tubing
  - 6. Job Sheet #6 — Make a 45-Degree Offset Bend in Copper Tubing
  - 7. Job Sheet #7 — Cut, Ream, and Join Copper Tubing Using a Flare Joint
  - 8. Job Sheet #8 — Cut, Ream, and Join Copper Tubing Using the Compression Method
  - 9. Job Sheet #9 — Cut, Ream, and Join Copper Tubing Using the Sweat Method
  - 10. Job Sheet #10 — Cut, Ream, and Join Copper Tubing Using the Swage Method
  - 11. Job Sheet #11 — Construct a Tubing Project
  - 12. Job Sheet #12 — Measure and Mark a Predetermined Length of Pipe



## SUGGESTED ACTIVITIES

13. Job Sheet #13 — Cut, Ream, and Thread a Piece of One-Inch Steel Pipe

14. Job Sheet #14 — Cut, Ream, and Join Plastic Pipe

G. Test

H. Answers to test

II. Instructor's guide

A. Review unit and plan presentation.

B. Obtain material to supplement unit.

1. Equipment and materials for procedures outlined in the job sheets

2. Resource materials

a. Latest edition of *Refrigeration and Air Conditioning* by Lee Miles.

(NOTE: Order from Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 07632.)

b. Latest edition of *Refrigeration and Air-Conditioning Technology* by William C. Whitman and William M. Johnson.

(NOTE: Order from Delmar Publishers, Inc., 2 Computer Drive West, Box 15-015, Albany, New York 12212.)

c. Latest edition of *Sheet Metal Blueprint Reading for the Building Trades* by Claude J. Zinngarbe.

(NOTE: Order from Delmar Publishers, Inc., 2 Computer Drive West, Box 15-015, Albany, New York, 12212.)

d. Latest editions of *Air Conditioning and Refrigeration Fundamentals* by Gary Wantiez and *Air Conditioning and Refrigeration Book III and Book IV* by William Eckes and Dan Fulkerson.

(NOTE: Order from Mid-America Vocational Curriculum Consortium, Inc., Oklahoma State Department of Vo-Tech Education, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074-4364.)

3. Competency profiles

(NOTE: A master of the competency profile for this book is provided at the front of the instructor edition. You may duplicate the profile and distribute it to students as needed.)

## SUGGESTED ACTIVITIES

- C. Introduce unit to students.
- Discuss basic skills used in HVAC operations.
  - Discuss procedures for completing the basic skills.
  - Discuss HVAC units and the components for those units.
  - Discuss and emphasize the importance of proper safety precautions pertaining to HVAC operations.
- D. Provide students with objective sheet.
- E. Discuss unit and specific objectives.
- F. Provide students with information, assignment, and job sheets.
- G. Discuss information, assignment, and job sheets.
1. Use Information Sheet, Section I, to discuss terms and definitions associated with HVAC basic skills.
    - Have students review terms and definitions.
    - Show students samples of terms if appropriate.
    - Point out the importance of understanding these terms and definitions and how this will help them to better understand this unit.
  2. Use Information Sheet, Section II, to discuss types of HVAC units.
    - Discuss the various types of HVAC units.
    - Invite a HVAC contractor to visit with the class and discuss the various types of HVAC units, their components, how they compare with each other and what their functions are.
    - Display illustrations of the various units, and then have students play a game in which they identify and describe the use of each unit.
  3. Use Information Sheet, Sections III through VIII, to discuss the components of various types of units or systems.
    - Take students on a field trip to construction sites where they can observe different types of units being installed. Discuss the different types of units, the components for these units, and the different installation methods that may be used.
    - Emphasize proper safety when working with these units.





## SUGGESTED ACTIVITIES

4. Use Information Sheet, Section IX, to discuss basic skills used in HVAC operations.
  - Discuss with students how many of these skills they observed while visiting the construction sites. How many other skills were in use?
  - Discuss the importance of being able to perform each of these skills properly.
  - Demonstrate proper methods used to complete these skills.
  - Observe students while they practice and demonstrate the various skills. If the students do not do them properly, correct them; then have them practice some more.
  - Have students complete the assignment sheets.
  - Demonstrate the procedures in the job sheets pertaining to each of these skills.
  - Discuss the procedures with the students, and then have them complete each of the job sheets.

H. Give test.

I. Critique test and discuss in class.

J. Reteach and retest as necessary.

K. Complete appropriate section of competency profiles.

### III. Unit references

- A. Eckes, William and Dan Fulkerson. *Air Conditioning and Refrigeration Book III*. Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, Inc., 1981.
- B. Eckes, William and Dan Fulkerson. *Air Conditioning and Refrigeration Book IV*. Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, Inc., 1981.
- C. Miles, Lee. *Refrigeration and Air Conditioning*. 2nd ed. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1987.
- D. Wantiez, Gary W. *Air Conditioning and Refrigeration Fundamentals*. Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, Inc., 1984.
- E. Zinngrabe, Claude J., *Sheet Metal Blueprint Reading for the Building Trades*. Albany, New York: Delmar Publishers, a division of Litton Educational Publishing, Inc., 1984.

HVAC BASIC SKILLS  
UNIT IV

## INFORMATION SHEET

## I. Terms and definitions associated with HVAC

- A. **Hydronics** — The science of heating with water
- B. **Heat pump** — Air-conditioning system that is reversible so as to be able to remove heat from or add heat to a given space or material upon demand
- C. **Dehumidifier** — Device used to remove moisture from air in enclosed space
- D. **Hermetic system** — Refrigeration system that has a compressor driven by a motor contained in compressor dome or housing
- E. **Filter** — Device or material installed in the air circulation system of a furnace to remove dust particles and pollen
- F. **Compressor** — Pump of a refrigerating mechanism which draws a vacuum or low pressure on cooling side of refrigerant cycle and squeezes or compresses the gas into the high pressure or condensing side of the cycle
- G. **Condenser** — Part of the refrigeration mechanism which receives hot, high-pressure refrigerant gas from compressor and cools gaseous refrigerant until it returns to liquid state
- H. **Evaporator** — Part of a refrigerating mechanism in which the refrigerant evaporates and absorbs heat
- I. **Metering device** — A device that controls the flow of liquid refrigerant into the evaporator
- J. **Refrigerant** — Any substance which produces a refrigerating effect by its absorption of heat while evaporating
- K. **Refrigerant oil** — Special dehydrated oil used in refrigeration mechanism for lubrication and cooling
- L. **F.P.T.** — Female pipe taper
- M. **M.P.T.** — Male pipe taper

## II. Types of HVAC units

## A. Heating units

## 1. Gas-forced air furnaces

- a. High boy (upflow)
- b. Low boy
- c. Horizontal
- d. Counterflow (downflow)



## INFORMATION SHEET

## 2. Oil-forced air furnaces

- |                      |                           |
|----------------------|---------------------------|
| a. High boy (upflow) | c. Horizontal             |
| b. Low boy           | d. Counterflow (downflow) |

## 3. Electric furnaces

- |                           |                  |
|---------------------------|------------------|
| a. Central heating system | c. Space heaters |
| b. Radiant heating system | d. Duct heaters  |

## 4. Hydronics

- |                 |                  |
|-----------------|------------------|
| a. Hot water    | c. Chilled water |
| b. Steam boiler |                  |

## 5. Heat pumps

- |                   |                 |
|-------------------|-----------------|
| a. Air to air     | c. Air to water |
| b. Water to water | d. Water to air |

## 6. Solid fuel furnaces

- |            |         |
|------------|---------|
| a. Coal    | c. Coke |
| b. Lignite | d. Wood |

## B. Ventilating systems (air distribution systems)

1. Exhaust
2. Dilution
3. Combinations of exhaust and dilution

## C. Cooling systems

1. Evaporative
2. Absorption
3. Remote
4. Split

## INFORMATION SHEET

## D. Humidifiers

1. Atomizing
2. Plate or pan
3. Evaporation or wetted element

## E. Dehumidifier

(NOTE: Dehumidifier is a small hermetic refrigerating system with an evaporator and condenser both enclosed in a cabinet.)

## F. Filters

1. Electronic
2. Mechanical
3. Special (charged) media

## III. Major components of a forced-air gas furnace system

- A. Burner assembly
- B. Combustion chamber
- C. Heat exchanger
- D. Flue-vent system
- E. Draft diverter or damper
- F. Blower assembly
- G. Air filters
- H. Safety and operation controls

## IV. Major components of a forced-air oil furnace system

- A. Oil pump
- B. Air blower
- C. Electric motor
- D. Ignition transformer
- E. Blast tube and firing assembly
- F. Air filter
- G. Flue-vent system
- H. Safety and operation controls

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## INFORMATION SHEET

- V. Major components of an electric forced-air system
  - A. Blower and motor assembly
  - B. Air filter
  - C. Heating elements
  - D. Safety and operation controls
- VI. Major components of a heat pump
  - A. Indoor and outdoor refrigerant coils
  - B. Compressor
  - C. Indoor and outdoor metering devices
  - D. Indoor and outdoor check valves
  - E. 4-way reversing valve
  - F. Piston
  - G. Piston bleed parts
  - H. Crankcase heater
  - I. Accumulator
  - J. Indoor and outdoor blowers
  - K. Solenoid
- VII. Major components of a hydronic system
  - A. Burner
  - B. Boiler
  - C. Water pump
  - D. Water-pressure gauge
  - E. Temperature-sensing switch
  - F. Expansion chamber or compression tank
  - G. Pressure-relief valve
- VIII. Major components of a cooling system
  - A. Compressor
  - B. Condenser
  - C. Condenser fan
  - D. Liquid refrigerant line
  - E. Metering device
  - F. Evaporator (cooling coil)
  - G. Evaporator fan
  - H. Blower motor
  - I. Suction line
  - J. Filter

## INFORMATION SHEET

- IX. Basic skills used in HVAC operations
- A. Assemble duct and fittings
  - B. Install insulation on duct
  - C. Make compression-type flares
  - D. Make generating-type flares
  - E. Make swage joints
  - F. Make bends in tubing
  - G. Connect tubing to compression-type fitting
  - H. Connect tubing to flare-type fitting
  - I. Clean, flux, and solder a swage joint
  - J. Clean, flux, and solder a sweat-type fitting
  - K. Construct tubing projects
  - L. Measure pipe correctly
  - M. Cut iron pipe
  - N. Ream iron pipe
  - O. Thread iron pipe
  - P. Make iron pipe connections
  - Q. Cut PVC pipe
  - R. Ream PVC pipe
  - S. Make PVC pipe connections



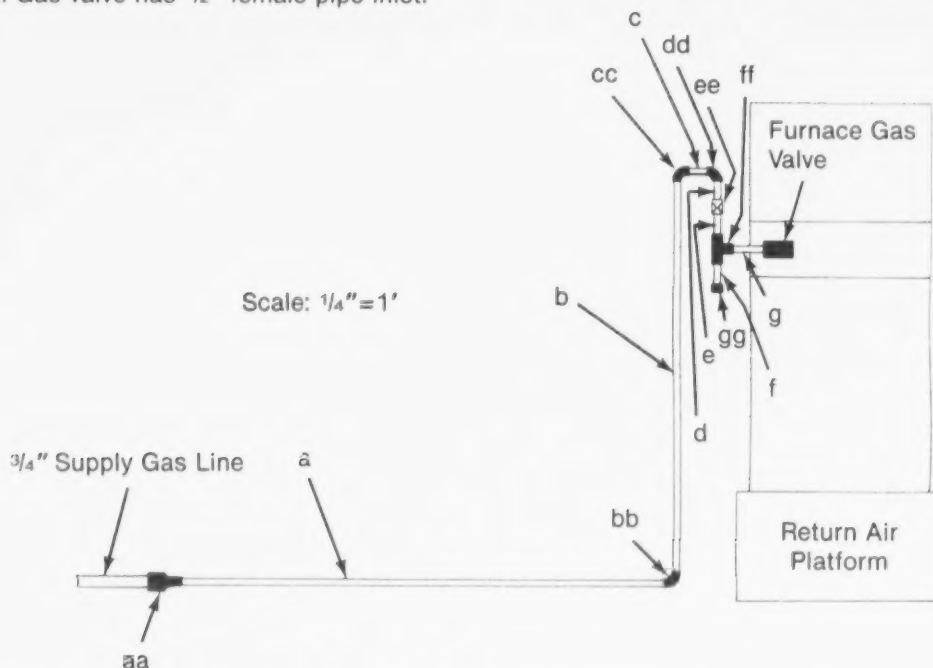
# HVAC BASIC SKILLS UNIT IV

## ASSIGNMENT SHEET #1 — DETERMINE PIPE LENGTHS AND FITTINGS NECESSARY TO CONNECT A GAS FURNACE

NAME \_\_\_\_\_

SCORE \_\_\_\_\_

Make a list of the pipe length and the fittings necessary to connect the gas furnace below to the supply gas line. Place a gas cock in the line prior to where the line enters the furnace cabinet. Gas valve has  $\frac{1}{2}$ " female pipe inlet.



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| Pipe Length | Size/Fitting |
|-------------|--------------|
| a. _____    | aa. _____    |
| b. _____    | bb. _____    |
| c. _____    | cc. _____    |
| d. _____    | dd. _____    |
| e. _____    | ee. _____    |
| f. _____    | ff. _____    |
| g. _____    | gg. _____    |



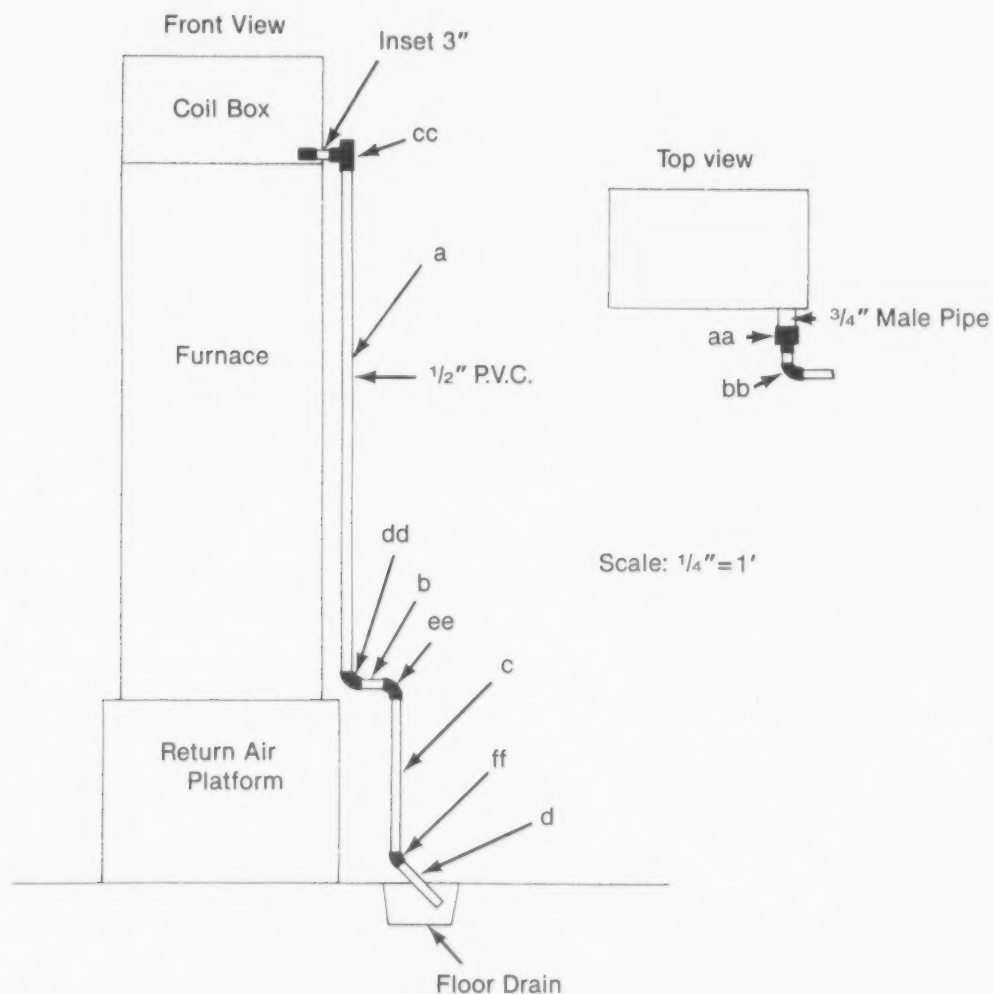
# HVAC BASIC SKILLS UNIT IV

## ASSIGNMENT SHEET #2 — DETERMINE LENGTHS OF PVC AND FITTINGS NECESSARY TO CONSTRUCT A CONDENSATE LINE

NAME \_\_\_\_\_

SCORE \_\_\_\_\_

Make a list of the lengths of PVC and fittings necessary to construct the condensate line on the system below. Condensate drain on coil is  $\frac{3}{4}$ " male pipe and comes straight out of coil box. Front of coil box sets back six inches which allows room for making connections.



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## ASSIGNMENT SHEET #2

## PVC lengths

- a. \_\_\_\_\_
- b. \_\_\_\_\_
- c. \_\_\_\_\_
- d. \_\_\_\_\_

## Fittings

Fitting (aa) connects to coil condensate drain.

Fitting (bb) enables the drain line to turn in a direction parallel to the top of the furnace.

- aa. \_\_\_\_\_
- bb. \_\_\_\_\_
- cc. \_\_\_\_\_
- dd. \_\_\_\_\_
- ee. \_\_\_\_\_
- ff. \_\_\_\_\_

HVAC BASIC SKILLS  
UNIT IV

## ANSWERS TO ASSIGNMENT SHEETS

(NOTE: Printing may cause size distortion on illustrations.)

## Assignment Sheet #1

- |             |                         |                   |
|-------------|-------------------------|-------------------|
| a. 11' - 6" | f. 11"                  | dd. 1/2" ell      |
| b. 9' - 3"  | g. 1' - 0"              | ee. 1/2" gas cock |
| c. 10"      | aa. 3/4" x 1/2" reducer | ff. 1/2" tee      |
| d. 11"      | bb. 1/2" ell            | gg. 1/2" cap      |
| e. 9"       | cc. 1/2" ell            |                   |

## Assignment Sheet #2

- |             |                         |                        |
|-------------|-------------------------|------------------------|
| a. 12' - 0" | aa. 3/4" F.P.T. to 1/2" | ee. 1/2" ell           |
| b. 9"       | bb. 1/2" ell            | ff. 1/2" 45-degree ell |
| c. 3' - 9"  | cc. 1/2" tee            |                        |
| d. 1' - 5"  | dd. 1/2" ell            |                        |



HVAC BASIC SKILLS  
UNIT IVJOB SHEET #1 — MAKE A FLARE WITH A COMPRESSION-  
TYPE FLARING BLOCK

## I. Tools and materials

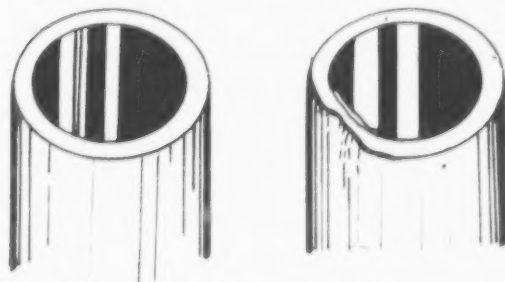
- A. Tubing cutter/reamer
- B. Compression-type flaring block
- C. Flaring tool
- D. Steel tape or folding rule
- E. Refrigeration oil
- F.  $\frac{3}{8}$ " copper tubing (soft rolled)
- G. One  $\frac{3}{8}$ " flare nut
- H. Safety goggles

## II. Procedure

- A. Put on safety goggles
- B. Unroll a section of copper tubing
- C. Measure and mark a 6" piece of the copper tubing
- D. Cut off tubing at the 6" mark
  - 1. Place cutter on tubing; do not overtighten
  - 2. Turn a few revolutions and then tighten a little more
  - 3. Continue to tighten a little bit at a time while turning the cutter until the tubing is cut

(NOTE: Cutter should not be so tight that it bends the end of the tubing. See Figure 1.)

FIGURE 1



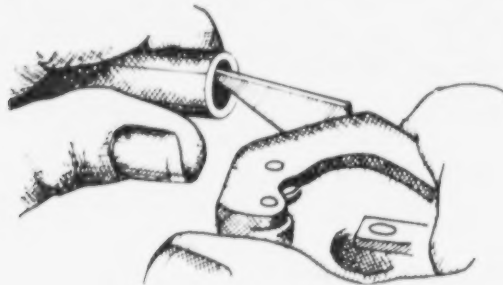
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## JOB SHEET #1

- E. Reseal the end of the roll of tubing
- F. Ream the cut piece of tubing (Figure 2)

FIGURE 2



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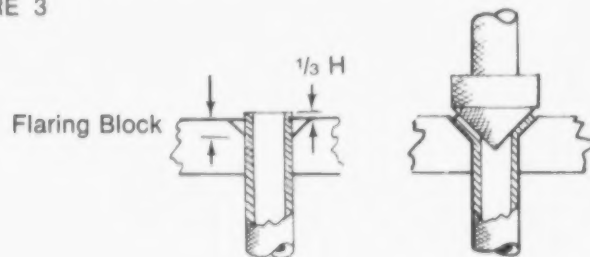
1. Don't overream; only remove the burrs
2. Point end of tubing slightly downward while reaming to let chips fall out

**CAUTION**

Do not blow into the end of the tubing.

- G. Place tubing in flaring block
- H. Extend tubing above the block  $\frac{1}{3}$  the depth of the block chamfer (Figure 3)

FIGURE 3



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- I. Place flaring tool on block
- J. Put a drop of refrigeration oil on the threads and a drop on the cone

(NOTE: Refrigeration oil should always be used when working with refrigeration-system components.)

- K. Tighten cone into tubing a few turns, then back out the cone

## JOB SHEET #1

L. Continue the tightening and loosening process until the flare is made

M. Do not overtighten the flaring tool

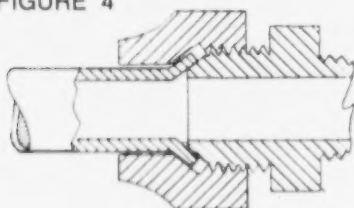
(NOTE: Overtightening will cause the tubing to wash out and may cause the flare to split, resulting in a bleed.)

N. Remove tubing from flaring block

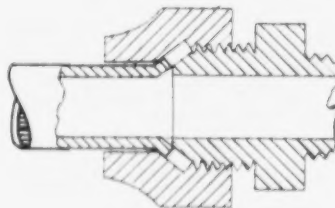
O. Place flare nut on the tubing

P. Check fit of flare in the seat of the flare nut (Figure 4)

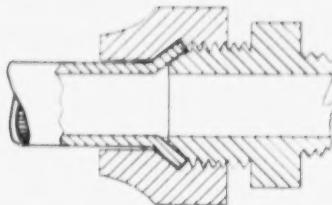
FIGURE 4



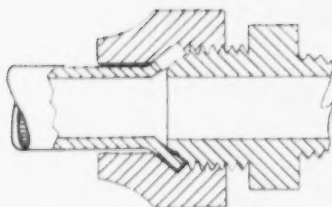
Properly Made Flare



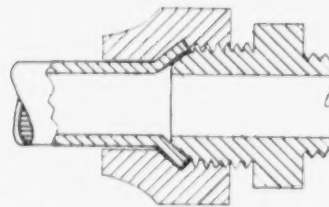
Flare Too Small



Flare Too Large



Flare Is Uneven



Tubing Was Not Reamed Before Flaring

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Q. Have instructor inspect work

R. Keep tubing for next job sheet

S. Clean up area and put tools away



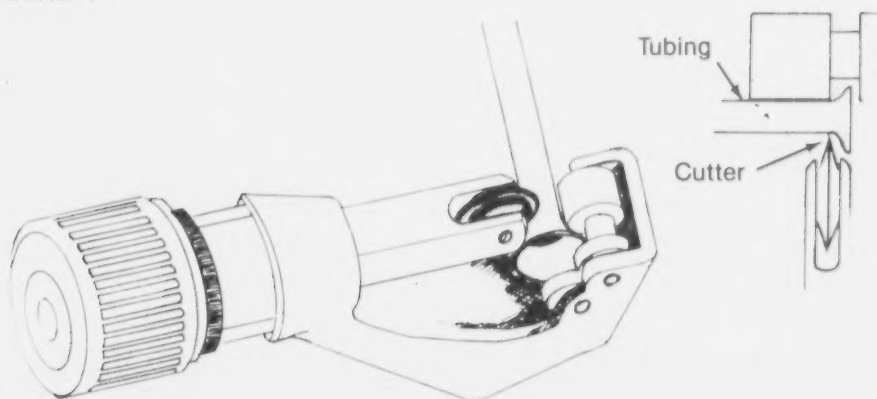
HVAC BASIC SKILLS  
UNIT IVJOB SHEET #2 — MAKE A FLARE WITH A GENERATING  
TYPE FLARING BLOCK

- I. Tools and materials
  - A. Tubing cutter/reamer
  - B. Generating-type flaring block
  - C. Flaring tool
  - D. Refrigeration oil
  - E.  $\frac{3}{8}$ " copper tubing used on Job Sheet #1
  - F.  $\frac{3}{8}$ " flare nut used on Job Sheet #1
  - G. Safety goggles

## II. Procedure

- A. Put on safety goggles
- B. Cut off previously made flare
  - 1. Place flare in slot-cutter roller (Figure 5)

FIGURE 5



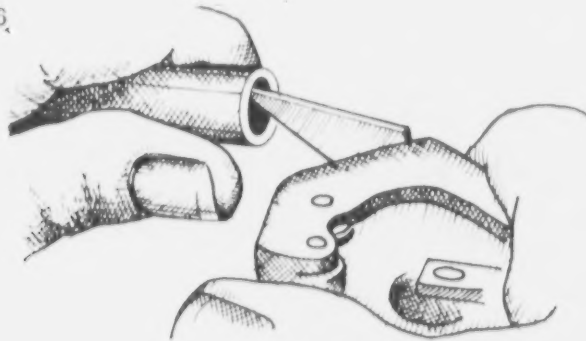
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## JOB SHEET #2

2. Tighten cutter wheel against the tubing
3. Turn a few revolutions and then tighten again
4. Continue this procedure until old flare is cut off

C. Ream cut piece of tubing (Figure 6)

FIGURE 6



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1. Do not overream; only remove the burr
2. Point end of tubing slightly downward while reaming to let chips fall out

**CAUTION**

Do not blow into end of tubing.

D. Place tubing in flaring block

(NOTE: Use the portion of the flaring tool below the slot as a height gauge. See Figure 7.)

FIGURE 7



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## JOB SHEET #2

- E. Place flaring tool on block
- F. Put a drop of refrigeration oil on the threads and a drop on the cone
- G. Tighten the cone into the tubing a few turns; then back out the cone
- H. Continue this process until the flare is made

(NOTE: This process makes a smooth, polished flare.)

- I. Remove tubing from block
- J. Place flare nut on tubing
- K. Check fit of flare in the seat of the flare nut
- L. Have instructor inspect work
- M. Keep tubing for next job sheet
- N. Clean up area and put tools away





HVAC BASIC SKILLS  
UNIT IV

## JOB SHEET #3 — MAKE A SWAGE JOINT

## I. Tools and materials

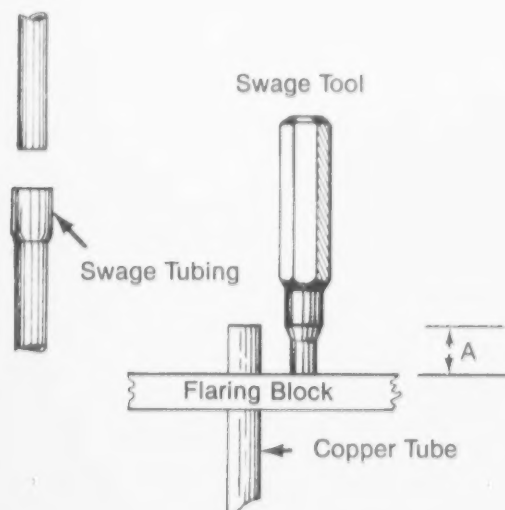
- A. Tubing used on Job Sheet #2
- B. Flaring block
- C.  $\frac{3}{8}$ " swage punch
- D. Ball-peen hammer

## II. Procedure

- A. Place tubing in block

(NOTE: Tubing must extend above the block the distance of part "A." See Figure 8.)

FIGURE 8



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- B. Check the distance by placing the punch adjacent to the tubing (Figure 8)

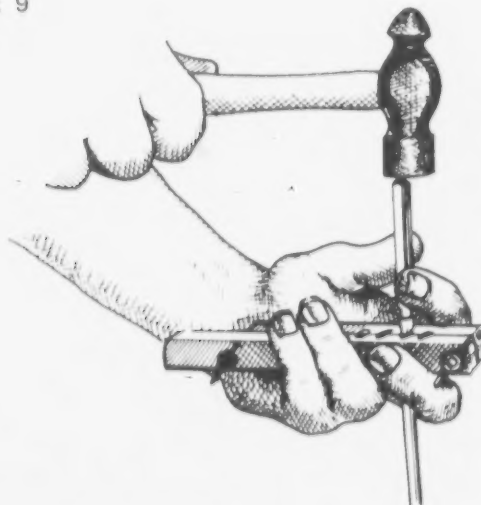


## JOB SHEET #3

## C. Hold block and tubing in hand

1. Have last two fingers underneath the block
2. Keep tubing between second and third fingers
3. Hold swage punch with thumb and index finger of same hand (Figure 9)

FIGURE 9



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## D. Tap punch lightly to start it into the tubing

## E. Hammer punch into the tubing

(NOTE: This will create a cup on the end of the tubing.)

**CAUTION**

Never hit the punch sideways because this will cause it to break off.

## F. Remove punch, twisting it if necessary in order to remove it

G. Check to see if  $\frac{3}{8}$ " o.d. tubing will fit into the cup with a close fit

## H. Have instructor inspect work

## I. Clean up area and put tools away

# HVAC BASIC SKILLS UNIT IV

## JOB SHEET #4 — MAKE A 90-DEGREE BEND IN COPPER TUBING

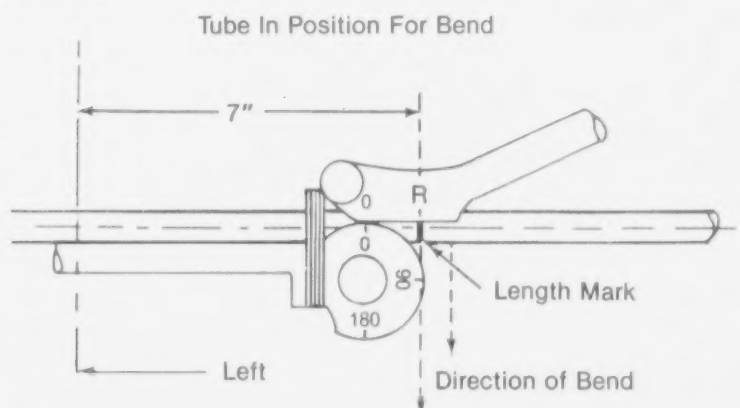
### I. Tools and materials

- A. Tubing cutter
- B.  $\frac{3}{8}$ " lever-type tubing bender
- C.  $\frac{3}{8}$ " o.d. soft drawn copper tubing
- D. Steel tape or folding rule

### II. Procedure

- A. Unroll a straight piece of copper tubing
- B. Measure and mark a 17" piece of tubing
- C. Cut off tubing at the 17" mark
- D. Place bender on tubing
- E. Measure in 7" on tubing and make a mark
- F. Align "R" mark on bender with mark on tubing (Figure 10)

FIGURE 10



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## JOB SHEET #4

- G. Observe how the bender fits on the tubing (Figure 10)
- H. Pull lever until "R" mark aligns with 90-degree mark on bender

(NOTE: Tubing will stretch approximately one tube diameter for each 90-degree of bend.)

- I. Remove bender
- J. Have instructor inspect work
- K. Keep tubing for use in Job Sheet #11

HVAC BASIC SKILLS  
UNIT IV

## JOB SHEET #5 — MAKE A 180-DEGREE BEND IN COPPER TUBING

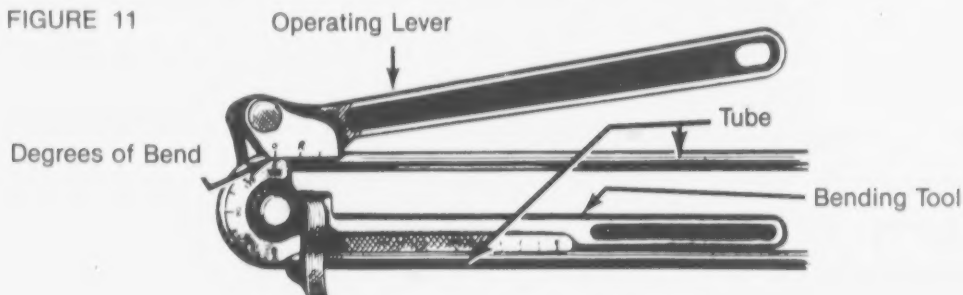
## I. Tools and materials

- A. Tubing cutter
- B.  $\frac{3}{8}$ " lever-type tubing bender
- C. Steel tape or folding rule
- D.  $\frac{3}{8}$ " o.d. soft-drawn copper tubing

## II. Procedure

- A. Unroll a straight piece of copper tubing
- B. Measure and mark a 12" piece of tubing and cut off
- C. Measure in 4" on tubing and make a mark
- D. Place bender on tube
- E. Align "R" mark on bender with mark on tubing
- F. Pull lever until "R" mark aligns with the 180-degree mark on bender (Figure 11)

FIGURE 11



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- G. Mark the spot on the tubing that aligns with the 180-degree mark on the bender
- H. Remove bender
- I. Have instructor inspect work
- J. Clean up area and put tools away



HVAC BASIC SKILLS  
UNIT IV

## JOB SHEET #6 — MAKE A 45-DEGREE OFFSET BEND IN COPPER TUBING

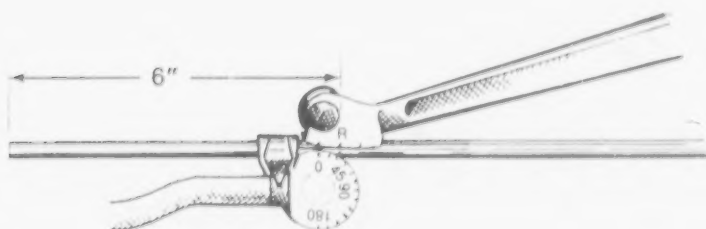
## I. Tools and materials

- A. Tubing cutter
- B.  $\frac{3}{16}$ " lever-type tubing bender
- C.  $\frac{3}{16}$ " o.d. soft-drawn copper tubing

## II. Procedure

- A. Unroll enough copper tubing to obtain a straight piece  $19 \frac{1}{4}$ " long and cut off
- B. Measure in 6" and make a mark on tubing
- C. Align "R" mark of bender with mark on tubing
- D. Pull lever until "R" mark aligns with 45-degree mark on bender (Figure 12)

FIGURE 12



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- E. Remove bender from tubing
- F. Measure  $4 \frac{1}{4}$ " from first mark and mark the tubing again

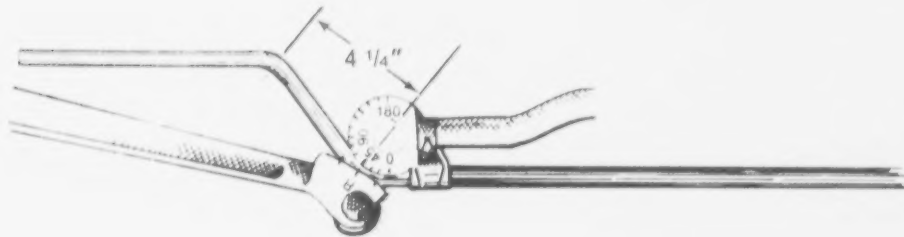


## JOB SHEET #6

- G. Align "R" mark on bender with mark on tubing

(NOTE: Bender must be on opposite side of the tubing from the previous bend.  
See Figure 13.)

FIGURE 13



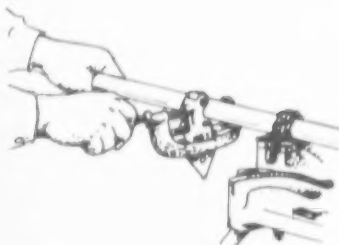
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- H. Pull lever until "R" mark aligns with 45-degree mark on bender
- I. Remove bender from tubing
- J. Have instructor inspect work
- K. Keep tubing for use in Job Sheet #11
- L. Clean up area and put tools away

HVAC BASIC SKILLS  
UNIT IVJOB SHEET #7 — CUT, REAM, AND JOIN COPPER TUBING USING  
A FLARE JOINT

- I. Tools and materials
  - A. Tubing cutter/reamer
  - B. Steel tape or folding rule
  - C. Flaring tool and block
  - D. Soft-drawn copper tubing
  - E. Fittings
  - F. Adjustable wrench
  - G. Open-end or flare-nut wrench
  - H. Hammer type flaring tool
  - I. Small ball peen hammer
  - J. Safety goggles
- II. Procedure using flaring tool and compression block
  - A. Put on safety goggles
  - B. Measure, mark, and cut a desired length of tubing
    1. Place cutter on tubing; do not overtighten (Figure 14)

FIGURE 14



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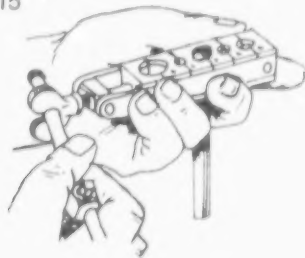




## JOB SHEET #7

2. Turn a few revolutions and then tighten a little more
  3. Continue to tighten a little at a time while turning cutter until tubing is cut  
(NOTE: Cutter should not be so tight that it bends the end of the tubing.)
- C. Slip flare nut over end of tubing
- D. Ream the end of the tubing
1. Do not over-ream; only remove the burrs
  2. Point end of tubing slightly downward while reaming to allow chips to fall out
- CAUTION**  
Do not blow into end of tubing.
- E. Place tubing in flare block
- F. Extend end of tubing above the block face about  $\frac{1}{8}$  the depth of the block chamfer (Figure 15)

FIGURE 15



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- G. Secure tubing in flaring block
- H. Place flaring tool on block
- (NOTE: Flaring tool must be kept oiled and clean.)
- I. Tighten cone into tubing a few turns; then back out the cone
- J. Continue the tightening and loosening process until the flare is made
- (NOTE: This process makes a smooth, polished flare and will lessen the chances of work hardening the tubing.)

## JOB SHEET #7

- K. Do not overtighten the flaring tool

(NOTE: Overtightening will cause the tubing to wash out and may cause the flare to split.)

- L. Remove flaring tool from block

- M. Remove tubing from flaring block

- N. Check fit of flare to seat of flare nut

- O. Secure flare nut tightly to flare fitting

- P. Duplicate process on other end of flare fitting

- Q. Have instructor check your work

III. Procedure using hammer-type flaring tool

- A. Measure and cut a desired length of tubing

1. Place cutter on tubing; do not overtighten
2. Turn a few revolutions and then tighten a little more
3. Continue to tighten a little at a time while turning cutter until tubing is cut

(NOTE: Cutter should not be so tight that it bends the end of the tubing.)

- B. Slip flare nut over end of tubing

- C. Ream the end of the tubing

1. Do not over-ream; only remove the burr
2. Point end of tubing slightly downward while reaming to allow chips to fall out

**CAUTION**

Do not blow into end of tubing.

- D. Clean inside end of tubing carefully

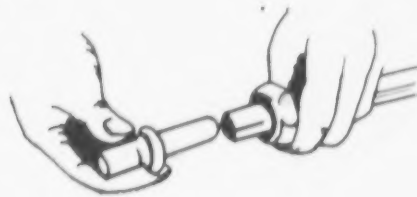
- E. Clean flaring tool carefully



## JOB SHEET #7

- F. Place end of flaring tool in end of pipe (Figure 16)

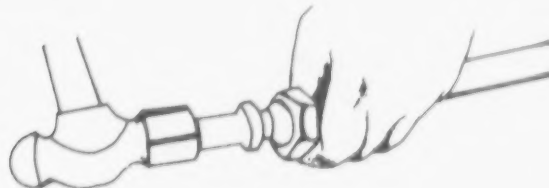
FIGURE 16



- G. Hold tubing and flaring tool in one hand, and drive flaring tool into tubing with hammer (Figure 17)

(NOTE: Tubing and flaring tool must be held straight.)

FIGURE 17



- H. Drive flaring tool into tubing until desired flare is formed

(NOTE: This may require checking flare on fitting.)

- I. Remove flaring tool from tubing

(NOTE: This may require turning flaring tool to loosen it.)

- J. Check fit of flare to seat of flare nut

- ~~K. Secure flare nut tightly to flare fitting~~

- L. Duplicate process on other end of flare fitting

- M. Have instructor check your work

- N. Clean up area and put tools away

Figures 16-17 used with permission of Mid-America Vocational Curriculum Consortium, Inc., Stillwater, OK

HVAC BASIC SKILLS  
UNIT IVJOB SHEET #8 — CUT, REAM, AND JOIN COPPER TUBING  
USING THE COMPRESSION METHOD

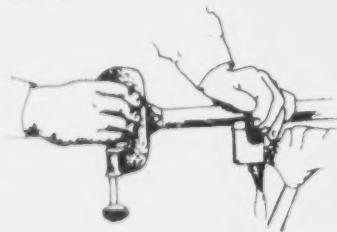
- I. Tools and materials
  - A. Tubing cutter/reamer
  - B. Steel tape or folding rule
  - C. Fitting, nut, and sleeve (ferrule)
  - D. Tubing
  - E. Open-end wrench or flare-nut wrench
  - F. Adjustable wrench
  - G. Safety goggles

## II. Procedure

- A. Put on safety goggles
- B. Measure, mark, and cut tubing to desired length
- C. Slip fitting nut and ferrule over end of tubing
- D. Ream end of tubing (Figure 18)

(NOTE: If tubing is reamed before installing fitting sleeve, the sleeve might not fit over end of tubing.)

FIGURE 18



Used with permission of Mid-America Vocational Curriculum Consortium, Inc., Stillwater, OK.

- E. Insert end of tubing into fitting

(NOTE: Tubing end must fit snugly against bottom of fitting socket.)

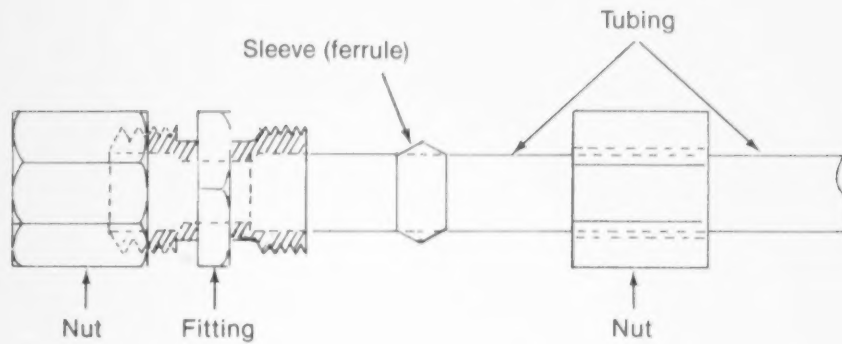
- F. Slide fitting nut and ferrule up against threaded end of fitting



## JOB SHEET #8

G. Make nut hand-tight on fitting (Figure 19)

FIGURE 19



H. Hold body of fitting with adjustable wrench

I. Turn fitting nut with flare-nut wrench or open-end wrench

(NOTE: Keep tubing tight against bottom of fitting socket while tightening nut.)

J. Complete tightening of nut on fitting

K. Duplicate process on other end of fitting

L. Have instructor check your work

M. Clean up area and put tools away

HVAC BASIC SKILLS  
UNIT IVJOB SHEET #9 — CUT, REAM, AND JOIN COPPER TUBING  
USING THE SWEAT METHOD

## I. Tools and materials

- A. Tubing cutter/reamer
- B. Steel tape or folding rule
- C. Sand cloth (emery cloth)
- D. Flux
- E. Torch and accessories
- F. Gas tank with wrench
- G. Striker
- H. Wire solder
- I. Dry wiping cloth
- J. Tubing
- K. Fitting
- L. Colored safety glasses

## II. Procedure

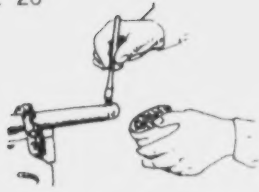
- A. Put on colored safety glasses
- B. Measure, mark, and cut tubing to desired length
- C. Ream end of cut tubing
- D. Clean tubing end with sand cloth
- E. Clean fitting socket with sand cloth
- F. Apply thin coat of flux to tubing end and fitting socket (See Figure 20 on the following page.)

(NOTE: A small brush used to apply the flux helps to keep out dirt.)



## JOB SHEET #9

FIGURE 20



G. Insert tubing end into fitting socket

(NOTE: Twist the tubing while inserting to spread the flux evenly.)

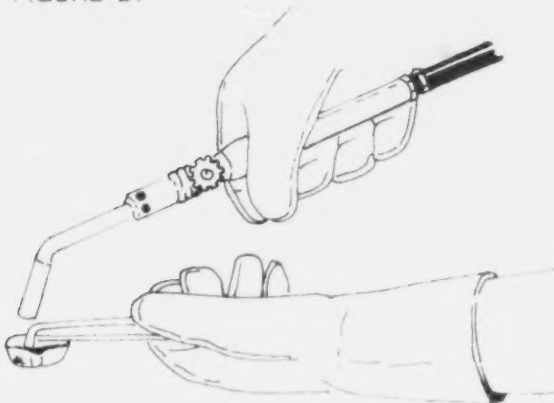
H. Wipe away excess flux with dry cloth

I. Secure tubing and fitting in vise carefully

J. Light and adjust torch (Figure 21)

(NOTE: Always use a striker.)

FIGURE 21



K. Apply heat to fitting (Figure 22)

(NOTE: The inner blue cone of the flame should be about  $\frac{1}{8}$ " from the fitting.)

FIGURE 22



Figures 20-22 used with permission of Mid-America Vocational Curriculum Consortium, Inc., Stillwater, OK.

## JOB SHEET #9

L. Move the torch flame around the entire joint

M. Apply solder (Figure 23)

(NOTE: Amount of solder is determined by size of tubing, i.e.,  $\frac{1}{2}$ " tubing will need approximately  $\frac{1}{2}$ " wire solder, and  $\frac{3}{4}$ " tubing needs  $\frac{3}{4}$ " wire solder.)

FIGURE 23



N. Discontinue heat and solder application when solder flows from joint

O. If necessary, wipe off excess solder with clean, dry cloth (Figure 24)

FIGURE 24



P. Turn off torch

Q. Allow solder to cool

(NOTE: Do not apply water to cool the fitting.)

R. Have instructor check your work

S. Clean up work area and put tools away

Figures 23-24 used with permission of Mid-America Vocational Curriculum Consortium, Inc., Stillwater, OK.





HVAC BASIC SKILLS  
UNIT IVJOB SHEET #10 — CUT, REAM, AND JOIN COPPER TUBING  
USING SWAGE METHOD

## I. Tools and materials

- A. Tubing cutter/reamer
- B. Steel tape or folding rule
- C. Flaring block
- D. Swage punch
- E. Ball-peen hammer
- F. Fine sand cloth or special pads

(NOTE: Do not use emery cloth when working with refrigerant lines.)

- G. Low-corrosive paste flux
- H. Air-acetylene torch outfit
- I. Colored safety glasses
- J. Striker
- K. 50-50 solder

(NOTE: If 50-50 solder is unavailable, ask instructor for a substitute soft solder.)

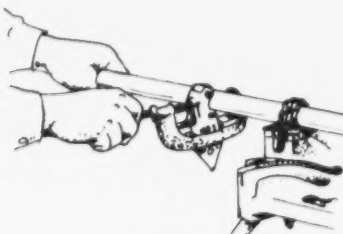
- L. Wood block
- M. Clean, dry cloth
- N. Hacksaw

## II. Procedure

- A. Measure, mark, and cut tubing to desired length

- 1. Place cutter on tubing; do not overtighten (Figure 25)

FIGURE 25



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## JOB SHEET #10

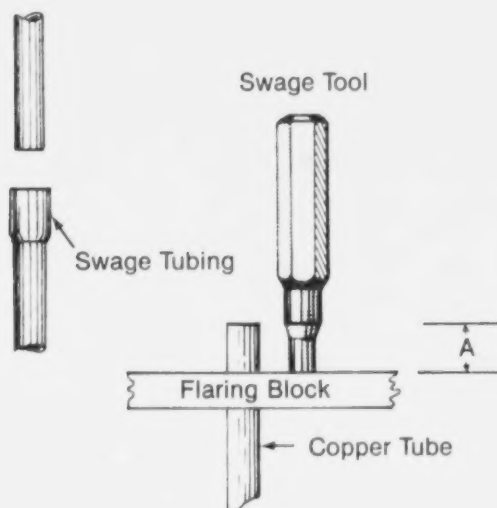
2. Turn a few revolutions; then tighten a little more
3. Continue to tighten a little at a time while turning cutter until tubing is cut  
(NOTE: Cutter should not be so tight that it bends the end of the tubing.)

## B. Make a swage joint

1. Place tubing in flaring block

(NOTE: Tubing must extend above the block the distance of "A" in Figure 26.)

FIGURE 26

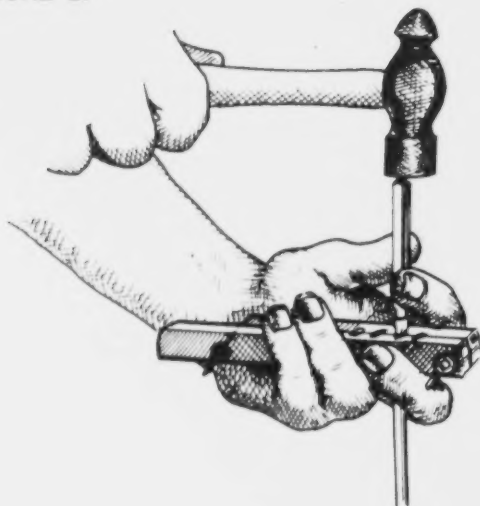


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2. Check the distance by placing the punch adjacent to the tubing (Figure 26)
3. Hold block and tubing in one hand (Figure 27)
  - a. Place last three fingers under block with second finger wrapped around tubing
  - b. Hold swage punch between thumb and index finger

## JOB SHEET #10

FIGURE 27



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4. Tap punch lightly with hammer to start it into the tubing
5. Continue tapping punch into the tubing

(NOTE: This will create a cup on the end of the tubing.)

**CAUTION**

Never hit the punch sideways as this will damage the tubing.

6. Remove punch, twisting it if necessary to remove it
  7. Check to see if other piece of tubing will fit into the cup with a close fit
- C. Remove tubing from the flaring block
  - D. Use sand cloth to clean the swage socket
  - E. Clean one end of the other piece of tubing
  - F. Do not touch cleaned surfaces

(NOTE: Oils and moisture from the skin will cause the cleaned surfaces to oxidize.)

- G. Use a clean brush to apply a thin film of flux to the piece to be inserted

**CAUTION**

Do not apply flux with fingers. Flux could easily be carried to the eyes and would be very harmful.

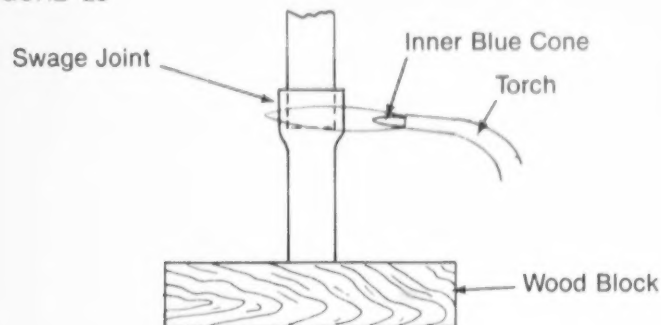


## JOB SHEET #10

- H. Insert tube until it reaches the bottom of the swage socket
- I. Twist the tube while inserting to spread the flux evenly
- J. Clean away excess flux with a clean, dry cloth
- K. Place tubing in wood block (Figure 28)

(NOTE: A wood block approximately 2" x 4" x 6" with various sizes of holes provides an adequate holding device for tubing projects. If a vise is used to hold the tubing, the swage joint should be well above the vise jaws. The vise jaws will absorb heat and make soldering difficult.)

FIGURE 28



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- L. Put on colored safety glasses
- M. Light and adjust torch
- N. Apply heat to swage joint (Figure 28)

(NOTE: The inner blue cone of the flame should be approximately 1/8" from the swage joint.)

- O. Move the torch around to heat the entire joint
- P. Apply solder to the joint

(NOTE: Do not melt solder with torch. When the tubing has been heated to the proper temperature, the solder will melt and flow into the swage joint.)

**CAUTION**

Overheating of tubing can cause solder to splash when applied.

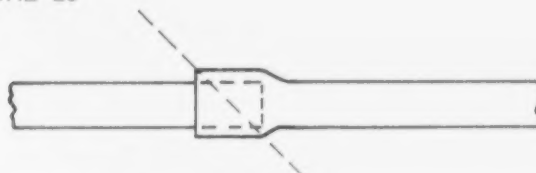
## JOB SHEET #10

- Q. Discontinue heat and solder application when solder flows from the joint

(NOTE: Do not continue to apply solder if it is not flowing into the joint. If the solder will not flow into the joint it will have to be disassembled, cleaned, and the soldering process repeated.)

- R. Turn off torch  
S. Allow solder to cool  
T. Clean the joint with a clean, dry cloth  
U. Have instructor inspect work  
V. Cut swage joint at a diagonal with a hacksaw (Figure 29)

FIGURE 29



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- W. Have instructor inspect the cut joint  
X. Clean up area and put tools away

HVAC BASIC SKILLS  
UNIT IV

## JOB SHEET #11 — CONSTRUCT A TUBING PROJECT

## I. Tools and materials

- A. Tubing cutter/reamer
- B. Steel tape or folding rule
- C. Flaring block
- D. Flaring tool
- E. Swage punch
- F.  $\frac{3}{8}$ " lever-type tubing bender
- G.  $\frac{3}{8}$ " soft-drawn copper tubing
- H.  $\frac{1}{4}$ " o.d. soft-drawn copper tubing
- I. Two  $\frac{1}{4}$ " flare nuts
- J. Two  $\frac{3}{8}$ " sweat tees
- K. Safety goggles

## II. Procedure

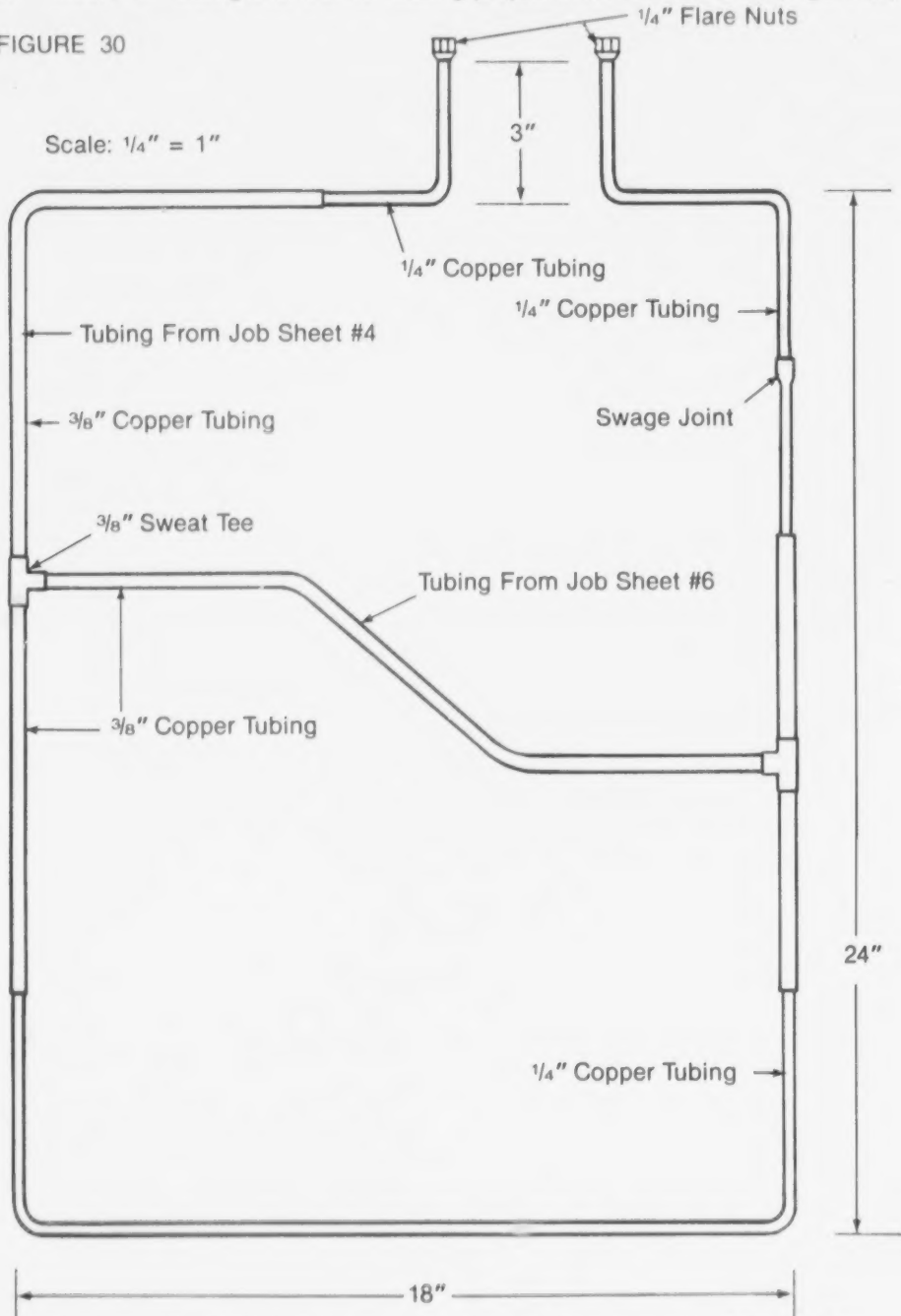
- A. Put on safety goggles
- B. Unroll, measure, and mark a straight piece of  $\frac{1}{4}$ " o.d. copper tubing 6" long
- C. Cut off tubing at mark
- D. Ream tubing
- E. Flare one end
- F. Place flare nut on tubing
- G. Measure down 3" from flare nut and mark tubing
- H. Place bender on tubing
- I. Make a 90-degree bend



## JOB SHEET #11

J. Insert  $\frac{1}{4}$ " tubing into the  $\frac{3}{8}$ " tubing project from Job Sheet #4 (Figure 30)

FIGURE 30



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## JOB SHEET #11

- K. Insert the other end of  $\frac{3}{8}$ " tubing into a  $\frac{3}{8}$ " sweat tee
- L. Cut a straight piece of  $\frac{3}{8}$ " o.d. tubing 8" long
- M. Insert one end into tee (See Figure 30 on previous page)
- N. Cut a straight piece of  $\frac{1}{4}$ " o.d. tubing 36" long
- O. Measure in 9" from both ends and make 90-degree bend (See Figure 30 on previous page)
- P. Cut a piece of straight  $\frac{3}{8}$ " o.d. tubing 5" long
- Q. Insert one end of the  $\frac{3}{8}$ " x 5" tubing into a sweat tee
- R. Cut a piece of straight  $\frac{3}{8}$ " o.d. tubing 3  $\frac{1}{2}$ " long
- S. Insert one end of the  $\frac{3}{8}$ " x 3  $\frac{1}{2}$ " tubing into the sweat tee (See Figure 30 on previous page)
- T. Cut a straight piece of  $\frac{1}{4}$ " o.d. tubing 6" long
- U. Ream one end
- V. Swage the reamed end
- W. Cut a straight piece of  $\frac{1}{4}$ " o.d. tubing 14  $\frac{1}{4}$ " long
- X. Ream one end
- Y. Flare the reamed end
- Z. Place flare nut on tubing
- AA. Measure down 3" from flare nut and mark tubing
- BB. Measure down 4  $\frac{1}{2}$ " from the first mark and make another mark
- CC. Make two 90-degree bends (See Figure 30 on previous page)
- DD. Place the 45-degree offset made on Job Sheet #6 between the two tees
- EE. Assemble the tubing project
- FF. Check the dimensions
- GG. Have instructor inspect work
- HH. Clean up area and put tools away





HVAC BASIC SKILLS  
UNIT IVJOB SHEET #12 — MEASURE AND MARK A PREDETERMINED LENGTH  
OF PIPE

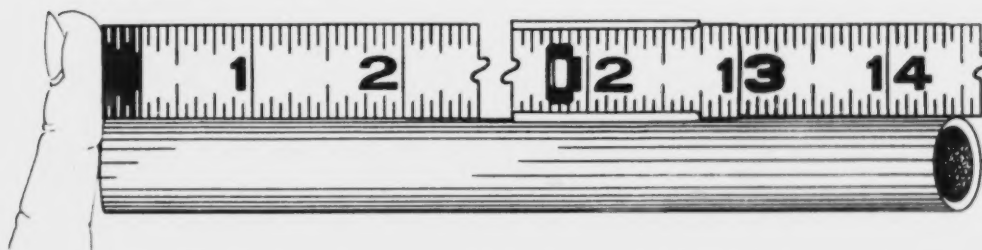
## I. Tools and materials

- A. Folding rule
- B. Pencil
- C. Piece of  $\frac{1}{2}$ " pipe

## II. Procedure

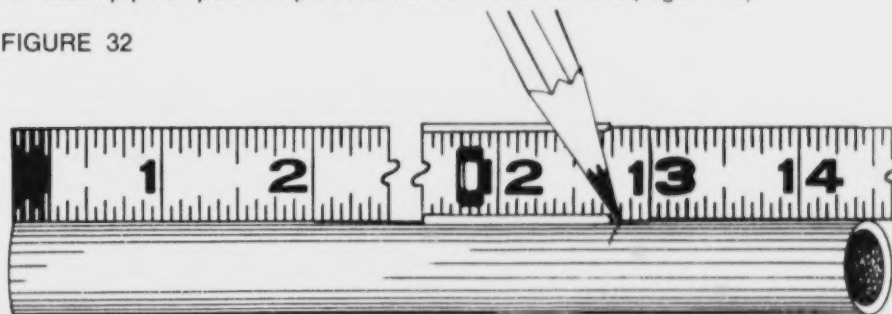
- A. Place pipe in suitable position for measuring and marking
- B. Determine correct measurement to be made
- C. Unfold rule and lay on top of pipe
- D. Place finger over end of pipe and butt rule against finger (Figure 31)

FIGURE 31



- E. Hold rule firmly on pipe and read predetermined measurement on rule
- F. Mark pipe at point of predetermined measurement (Figure 32)

FIGURE 32



## JOB SHEET #12

- G. Have instructor check your work
- H. Clean up work area and put away tools and materials

HVAC BASIC SKILLS  
UNIT IVJOB SHEET #13 — CUT, REAM, AND THREAD A PIECE OF  
ONE-INCH STEEL PIPE

## I. Tools and materials

- A. Die
- B. Die stock
- C. Pipe vise
- D. Wire brush
- E. Oil can (cutting oil)
- F. Piece of one-inch steel pipe
- G. Pencil
- H. Shop towel
- I. Safety glasses
- J. Pipe cutter
- K. Reamer
- L. Steel tape or folding rule
- M. Drip pan
- N. Pipe fitting

## II. Procedure

- A. Put on safety glasses
- B. Secure pipe in vise
- C. Measure and mark pipe at desired length
- D. Open pipe cutter until it will fit over pipe

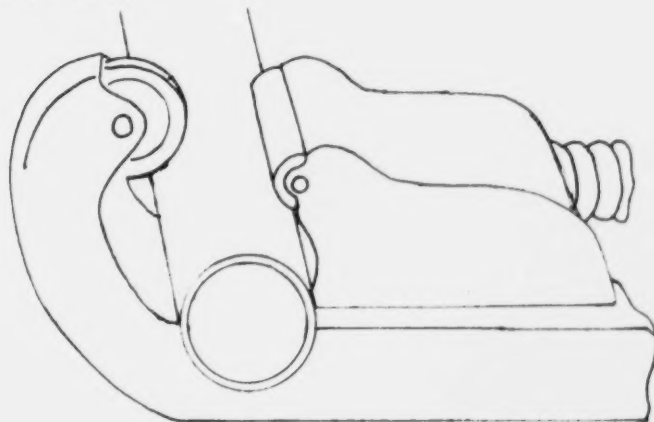
203



## JOB SHEET #13

- E. Locate cutter wheel on the pencil mark (Figure 33)

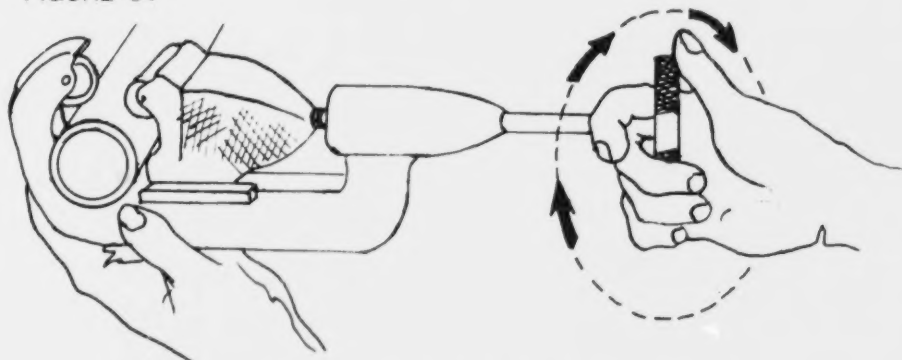
FIGURE 33



- F. Snug cutter up to pipe by rotating screw handle (Figure 34)

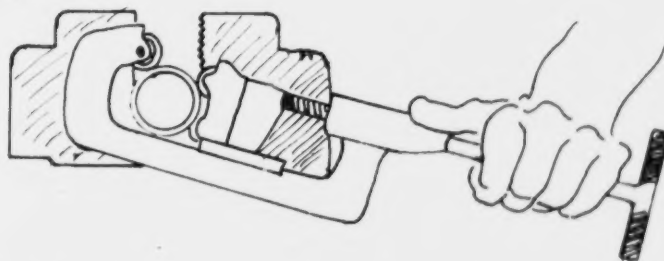
(NOTE: Don't overtighten as this can break cutter wheel.)

FIGURE 34



- G. Rotate cutter counterclockwise to start groove (Figure 35)

FIGURE 35



Figures 33-35 used with permission of Mid-America Vocational Curriculum Consortium, Inc., Stillwater, OK.

## JOB SHEET #13

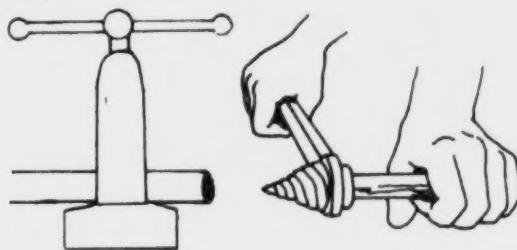
- H. Tighten cutter  $\frac{1}{4}$  of a turn for each full revolution around the pipe  
(NOTE: Overtightening can cause cutters to break.)
- I. Continue process until pipe is cut

**CAUTION**

When cutting short pieces of pipe, be careful not to cut your arm while rotating the cutter around the pipe.

- J. Clean pipe and cutter with shop towel
- K. Insert reamer tip in pipe (Figure 36)

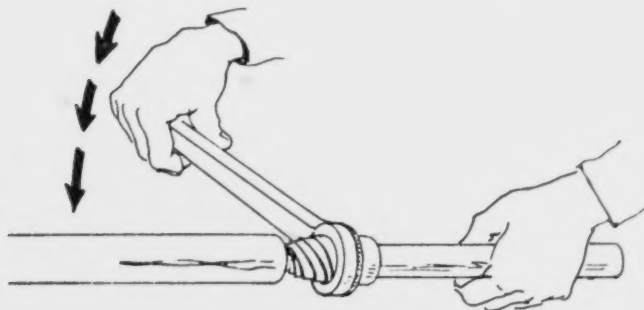
FIGURE 36



- L. Apply light forward pressure to push reamer into pipe
- M. Start rotating reamer (Figure 37)

(NOTE: Reamer should bite instantly if proper pressure is applied. Reamer can be damaged if rotated in the wrong direction.)

FIGURE 37



Figures 36-37 used with permission of Mid-America Vocational Curriculum Consortium, Inc., Stillwater, OK.

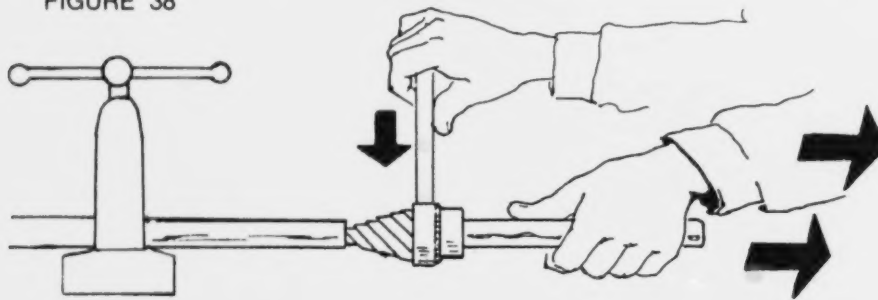


## JOB SHEET #13

- N. Rotate reamer until burrs are removed (Figure 38)
- O. Pull reamer back while continuing to rotate (Figure 38)

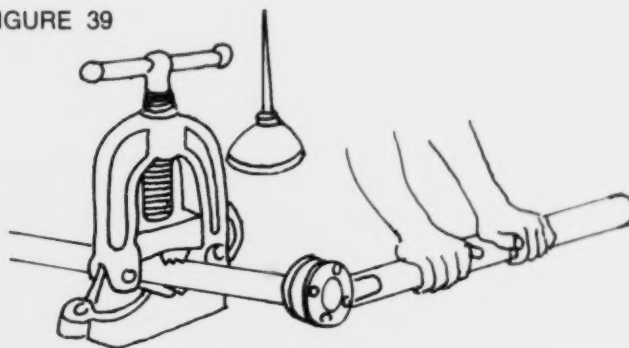
(NOTE: This prevents the reamer from leaving a burr.)

FIGURE 38



- P. Clean reamer with shop towel
- Q. Place drip pan under vise and end of pipe
- R. Lubricate end of pipe with cutting oil
- S. Secure and position ratchet die in die stock
- T. Place die on pipe
- U. Start die straight on the pipe
- V. Press die on pipe evenly and turn the die (Figure 39)

FIGURE 39



Figures 38-39 used with permission of Mid-America Vocational Curriculum Consortium, Inc., Stillwater, OK.

## JOB SHEET #13

- W. Continue to apply cutting oil while turning the die

(NOTE: Metal drip pan is used to catch dripping oil and steel cuttings.)

- X. Continue turning pipe die and cutting threads until the desired amount of threads have been cut

- Y. Reverse ratchet by turning lock 180 degrees, and remove die by turning counter-clockwise

(NOTE: Hold onto the die stock firmly while removing it, otherwise, die stock might fall when it comes to the end of the threads.)

- Z. Clean threads with a brush

**CAUTION**

Do not use compressed air for cleaning.

- AA. Have instructor check your work

- BB. Clean up area and put away tools and equipment



HVAC BASIC SKILLS  
UNIT IV

## JOB SHEET #14 — CUT, REAM, AND JOIN PLASTIC PIPE

## I. Tools and materials

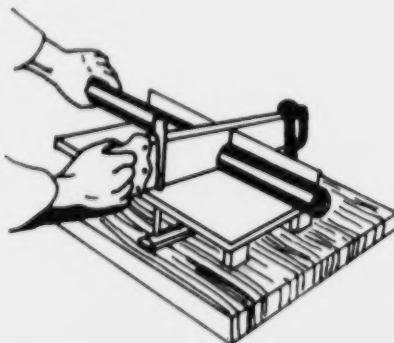
- A. Pipe cutter or handsaw with miter box
- B. Reamer or knife
- C. Cleaning solvent with brush or abrasive paper
- D. Solvent cement with brush
- E. PVC pipe
- F. PVC fittings
- G. Wiping cloth
- H. Flexible plastic pipe
- I. Plastic insert fittings
- J. Clamps
- K. Screwdriver
- L. Socket wrench

## II. Procedure for PVC pipe

- A. Measure and cut pipe to desired length

(NOTE: A miter box and miter saw ensure a square cut. See Figure 40.)

FIGURE 40



Used with permission of Mid-America Vocational Curriculum Consortium, Inc., Stillwater, OK.





## JOB SHEET #14

## B. Ream pipe

**CAUTION**

Since most PVC reaming is done with a pocket knife or other type of knife, care must be used in this operation.

## C. Apply solvent cleaner to pipe end of fitting socket

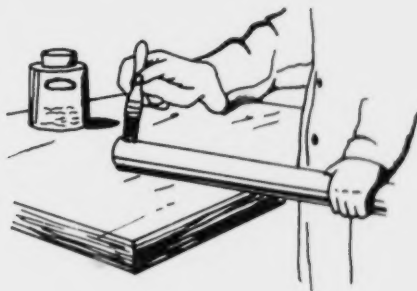
(NOTE: Abrasive paper such as sand cloth or emery cloth may be used.)

## D. Wipe solvent cleaner from the pipe end and fitting socket

(NOTE: This cleans the pipe and removes the gloss for better bonding.)

## E. Apply a light, even coat of solvent cement to the pipe end and fitting socket (Figure 41)

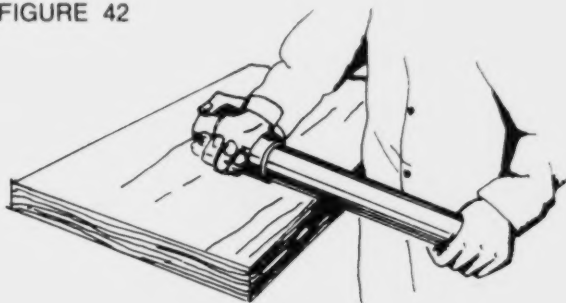
FIGURE 41



## F. Insert pipe all the way into the fitting socket while giving it a quarter turn (Figure 42)

(NOTE: This operation must be done quickly because the cement sets up in a few seconds.)

FIGURE 42



Figures 41-42 used with permission of Mid-America Vocational Curriculum Consortium, Inc., Stillwater, OK.

## JOB SHEET #14

- G. Allow 24 hours before testing PVC joints
  - H. Have instructor check your work
  - I. Clean up area and put away tools
- III. Procedure for flexible plastic pipe
- A. Measure and cut pipe to desired length
  - B. Ream pipe (Figure 43)

**CAUTION**

Since most flexible plastic pipe is cut and reamed with a knife, care must be used in this operation.

FIGURE 43



- C. Slip clamp over end of pipe

(NOTE: Open clamp enough for it to fit loosely on the pipe.)

- D. Hold pipe in one hand and the fitting in the other, and force fitting into end of pipe (Figure 44)

(NOTE: Cold [rigid] or heavy gauge pipe may need to be softened with hot water or a small flame from a torch.)

FIGURE 44



Figures 43-44 used with permission of Mid-America Vocational Curriculum Consortium, Inc., Stillwater, OK.

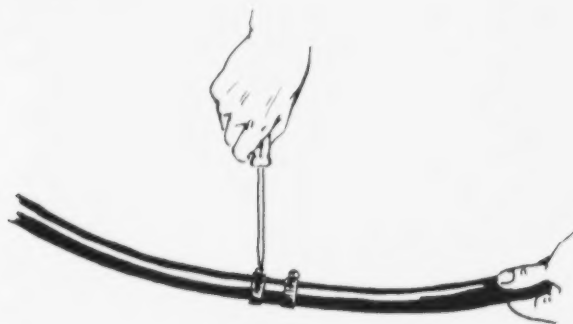


## JOB SHEET #14

- E. Slip clamp over inserted fitting and tighten with screwdriver (Figure 45)

(NOTE: Some clamps are fitted with hex nuts to accommodate socket wrenches.)

FIGURE 45



Used with permission of Mid-America Vocational Curriculum Consortium, Inc., Stillwater, OK.

- F. Complete same process on other end of fitting
- G. Have instructor check your work
- H. Clean up area and put tools away

# HVAC BASIC SKILLS UNIT IV

## TEST

NAME \_\_\_\_\_

SCORE \_\_\_\_\_

1. Match terms associated with HVAC basic skills with their correct definitions. Write the correct numbers in the blanks.

- |                                                                                                                                                                                                               |                     |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|
| _____a. Male pipe taper                                                                                                                                                                                       | 1. Dehumidifier     |
| _____b. Air-conditioning system that is reversible so as to be able to remove heat from or add heat to a given space or material upon demand                                                                  | 2. Condenser        |
| _____c. Device used to remove moisture from air in enclosed space                                                                                                                                             | 3. Refrigerant      |
| _____d. Refrigeration system that has a compressor driven by a motor contained in compressor dome or housing                                                                                                  | 4. Heat pump        |
| _____e. Device or material installed in the air circulation system of a furnace to remove dust particles and pollen                                                                                           | 5. Evaporator       |
| _____f. Pump of a refrigerating mechanism which draws a vacuum or low pressure on cooling side of refrigerant cycle and squeezes or compresses the gas into the high pressure or condensing side of the cycle | 6. Hermetic system  |
| _____g. Part of the refrigeration mechanism which receives hot, high-pressure refrigerant gas from compressor and cools gaseous refrigerant until it returns to liquid state                                  | 7. F.P.T.           |
| _____h. Part of a refrigerating mechanism in which the refrigerant evaporates and absorbs heat                                                                                                                | 8. Refrigerant oil  |
| _____i. A device that controls the flow of liquid refrigerant into the evaporator                                                                                                                             | 9. Compressor       |
| _____j. Any substance which produces a refrigerating effect by its absorption of heat while evaporating                                                                                                       | 10. Metering device |
| _____k. Special dehydrated oil used in refrigeration mechanism for lubrication and cooling                                                                                                                    | 11. Hydronics       |
| _____l. Female pipe taper                                                                                                                                                                                     | 12. M.P.T.          |
| _____m. The science of heating with water                                                                                                                                                                     | 13. Filter          |



## TEST

## 2. Name types of HVAC units.

## a. Name two types for each of the following heating units.

## 1) Gas-forced air furnaces

a) \_\_\_\_\_

b) \_\_\_\_\_

## 2) Oil-forced air furnaces

a) \_\_\_\_\_

b) \_\_\_\_\_

## 3) Electric furnaces

a) \_\_\_\_\_

b) \_\_\_\_\_

## 4) Hydronics

a) \_\_\_\_\_

b) \_\_\_\_\_

## 5) Heat pumps

a) \_\_\_\_\_

b) \_\_\_\_\_

## 6) Solid fuel furnaces

a) \_\_\_\_\_

b) \_\_\_\_\_

## b. Name two types of ventilating systems.

1) \_\_\_\_\_

2) \_\_\_\_\_

## c. Name two types of cooling systems.

1) \_\_\_\_\_

2) \_\_\_\_\_

## TEST

- d. Name two types of humidifiers.
- 1) \_\_\_\_\_
- 2) \_\_\_\_\_
- e. Name two types of filters.
- 1) \_\_\_\_\_
- 2) \_\_\_\_\_
3. Name five major components of a forced-air gas furnace system.
- a. \_\_\_\_\_
- b. \_\_\_\_\_
- c. \_\_\_\_\_
- d. \_\_\_\_\_
- e. \_\_\_\_\_
4. Name five major components of a forced-air oil furnace system.
- a. \_\_\_\_\_
- b. \_\_\_\_\_
- c. \_\_\_\_\_
- d. \_\_\_\_\_
- e. \_\_\_\_\_
5. Name two major components of an electric forced-air system.
- a. \_\_\_\_\_
- b. \_\_\_\_\_
6. Name six major components of a heat pump.
- a. \_\_\_\_\_
- b. \_\_\_\_\_
- c. \_\_\_\_\_
- d. \_\_\_\_\_
- e. \_\_\_\_\_
- f. \_\_\_\_\_



## TEST

7. Name four major components of a hydronic system.

- a. \_\_\_\_\_
- b. \_\_\_\_\_
- c. \_\_\_\_\_
- d. \_\_\_\_\_

8. Name seven major components of a cooling system.

- a. \_\_\_\_\_
- b. \_\_\_\_\_
- c. \_\_\_\_\_
- d. \_\_\_\_\_
- e. \_\_\_\_\_
- f. \_\_\_\_\_
- g. \_\_\_\_\_

9. Select the basic skills used in HVAC operations. Write an "X" in the blank before each correct answer.

- \_\_\_\_ a. Assemble duct and fittings
- \_\_\_\_ b. Install insulation on duct
- \_\_\_\_ c. Make compression-type flares
- \_\_\_\_ d. Make generating-type flares
- \_\_\_\_ e. Make swage joints
- \_\_\_\_ f. Make sweat-type flares
- \_\_\_\_ g. Make bends in tubing
- \_\_\_\_ h. Connect tubing to compression-type fitting
- \_\_\_\_ i. Connect tubing to flare-type fitting
- \_\_\_\_ j. Clean, flux, and solder a swage joint
- \_\_\_\_ k. Clean, flux, and solder a sweat-type fitting
- \_\_\_\_ l. Construct tubing project
- \_\_\_\_ m. Measure pipe correctly
- \_\_\_\_ n. Cut cast-iron pipe

## TEST

- \_\_\_\_\_o. Ream cast-iron pipe
- \_\_\_\_\_p. Thread iron pipe
- \_\_\_\_\_q. Make iron pipe connections
- \_\_\_\_\_r. Cut PVC pipe
- \_\_\_\_\_s. Ream PVC pipe
- \_\_\_\_\_t. Thread PVC pipe
- \_\_\_\_\_u. Make PVC pipe connections

(NOTE: Test questions 10 through 12 list the assignment sheets and job sheets which are an important part of this test. If they have not been completed, check with your instructor.)

- 10. Determine pipe lengths and fittings necessary to connect a gas furnace.
- 11. Determine lengths of PVC and fittings necessary to construct a condensate line.
- 12. Demonstrate the ability to
  - a. Make a flare with compression-type flaring block.
  - b. Make a flare with generating-type flaring block.
  - c. Make a swage joint.
  - d. Make a 90-degree bend in copper tubing.
  - e. Make a 180-degree bend in copper tubing.
  - f. Make a 45-degree offset bend in copper tubing.
  - g. Cut, ream, and join copper tubing using a flare joint.
  - h. Cut, ream, and join copper tubing using the compression method.
  - i. Cut, ream, and join copper tubing using the sweat method.
  - j. Cut, ream, and join copper tubing using the swage method.
  - k. Construct a tubing project.
  - l. Measure and mark a predetermined length of pipe.
  - m. Cut, ream, and thread a piece of one-inch steel pipe.
  - n. Cut, ream, and join plastic pipe.





# HVAC BASIC SKILLS UNIT IV

## ANSWERS TO TEST

1. a. 12      d. 6      g. 2      j. 3      m. 11  
     b. 4      e. 13      h. 5      k. 8  
     c. 1      f. 9      i. 10      l. 7

2. Answer should include any two for each of the following.

a. Heating units

1) Gas-forced air furnaces

- a) High boy (upflow)  
 b) Low boy

- c) Horizontal  
 d) Counterflow (downflow)

2. Oil-forced air furnaces

- a) High boy (upflow)  
 b) Low boy

- c) Horizontal  
 d) Counterflow (downflow)

3. Electric furnaces

- a) Central heating system  
 b) Radiant heating system

- c) Space heaters  
 d) Duct heaters

4. Hydronics

- a) Hot water  
 b) Steam boiler

- c) Chilled water

5. Heat pumps

- a) Air to air  
 b) Water to water

- c) Air to water  
 d) Water to air

6. Solid fuel furnaces

- a) Coal  
 b) Lignite

- c) Coke  
 d) Wood

b. Ventilating systems

- 1) Exhaust  
 2) Dilution

- 3) Combinations of exhaust  
 and dilution

c. Cooling systems

- 1) Evaporative  
 2) Absorption

- 3) Remote  
 4) Split



## ANSWERS TO TEST

- d. Humidifiers
    - 1) Atomizing
    - 2) Plate or pan
    - 3) Evaporative or wetted element
  - e. Filters
    - 1) Electronic
    - 2) Mechanical
    - 3) Special (charged) media
3. Answer should include any five of the following.
- a. Burner assembly
  - b. Combustion chamber
  - c. Heat exchanger
  - d. Flue-vent system
  - e. Draft diverter or damper
  - f. Blower assembly
  - g. Air filters
  - h. Safety and operation controls
4. Answer should include any five of the following.
- a. Oil pump
  - b. Air blower
  - c. Electric motor
  - d. Ignition transformer
  - e. Blast tube and firing assembly
  - f. Air filter
  - g. Flue-vent system
  - h. Safety and operation controls
5. Answer should include any two of the following.
- a. Blower and motor assembly
  - b. Air filter
  - c. Heating elements
  - d. Safety and operation controls
6. Answer should include any six of the following.
- a. Indoor and outdoor refrigerant coils
  - b. Compressor
  - c. Indoor and outdoor metering devices
  - d. Indoor and outdoor check valves
  - e. 4-way reversing valve
  - f. Piston
  - g. Piston bleed parts
  - h. Crankcase heater
  - i. Accumulator
  - j. Indoor and outdoor blowers
  - k. Solenoid

## ANSWERS TO TEST

7. Answer should include any four of the following.
- a. Burner
  - b. Boiler
  - c. Water pump
  - d. Water-pressure gauge
  - e. Temperature-sensing switch
  - f. Expansion chamber or compression tank
  - g. Pressure-relief valve
8. Answer should include any seven of the following.
- a. Compressor
  - b. Condenser
  - c. Condenser fan
  - d. Liquid refrigerant line
  - e. Metering device
  - f. Evaporator (cooling coil)
  - g. Evaporator fan
  - h. Blower motor
  - i. Suction line
  - j. Filter
9. a, b, c, d, e, g, h, i, j, k, l, m, p, q, r, s, u
10. Evaluated to the satisfaction of the instructor.
11. Evaluated to the satisfaction of the instructor.
12. a. Performance skills evaluated to the satisfaction of the instructor.  
b. Performance skills evaluated to the satisfaction of the instructor.  
c. Performance skills evaluated to the satisfaction of the instructor.  
d. Performance skills evaluated to the satisfaction of the instructor.  
e. Performance skills evaluated to the satisfaction of the instructor.  
f. Performance skills evaluated to the satisfaction of the instructor.  
g. Performance skills evaluated to the satisfaction of the instructor.  
h. Performance skills evaluated to the satisfaction of the instructor.  
i. Performance skills evaluated to the satisfaction of the instructor.  
j. Performance skills evaluated to the satisfaction of the instructor.  
k. Performance skills evaluated to the satisfaction of the instructor.  
l. Performance skills evaluated to the satisfaction of the instructor.  
m. Performance skills evaluated to the satisfaction of the instructor.  
n. Performance skills evaluated to the satisfaction of the instructor.

